PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 19 February 2001 (19.02.01)	
International application No. PCT/FI00/00635	**Applicant's or agent's file reference** OP100021/JUM
International filing date (day/month/year) 10 July 2000 (10.07.00)	**Priority date** (day/month/year) 09 July 1999 (09.07.99)
Applicant SALMELA, Olli et al	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   10 January 2001 (10.01.01)

   [ ] in a notice effecting later election filed with the International Bureau on:

   _____

2. The election [X] was

   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740 14 35

Authorized officer

Marie-José Devillard

Telephone No.: (41-22) 338 83 38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

OULUN PATENTTITOIMISTO
Berggren Oy AB
Teknologiantie 14 D
FIN-90570 Oulu
FINLANDE

Date of mailing (day/month/year)	
19 February 2001 (19.02.01)	
Applicant's or agent's file reference	**IMPORTANT NOTIFICATION**
OP100021/JUM	
International application No.	**International filing date (day/month/year)**
PCT/FI00/00635	10 July 2000 (10.07.00)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
BERGGREN OY AB P.O. Box 16 FIN-00101 Helsinki Finland		
	Telephone No.: +358-9-693701	
	Facsimile No.: +358-9-6933944	
	Teleprinter No.:	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
OULUN PATENTTITOIMISTO Berggren Oy AB Teknologiantie 14 D FIN-90570 Oulu Finland		
	Telephone No.: +358 8 511 5670	
	Facsimile No.: +358 8 556 6701	
	Teleprinter No.:	

3. Further observations, if necessary:
Please also not the change of file reference number.

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Marie-José Devillard
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

OULUN PATENTTITOIMISTO
Berggren Oy AB
Teknologiantie 14 D
FIN-90570 Oulu
FINLANDE

Date of mailing (day/month/year)	
09 November 2001 (09.11.01)	
Applicant's or agent's file reference	**IMPORTANT NOTIFICATION**
OP100021/JUM	
International application No.	**International filing date (day/month/year)**
PCT/FI00/00635	10 July 2000 (10.07.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
NOKIA NETWORKS OY P.O. Box 300 FIN-00045 Nokia Group Finland	FI	FI
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
NOKIA CORPORATION Keilalahdentie 4 FIN-02150 Espoo Finland	FI	FI
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Marie-José DEVILLARD

PATENT COOPERATION TREATY

10/020502

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

OULUN PATENTTITOIMISTO
Berggren Oy AB
Teknologiantie 14 D
FIN-90570 Oulu
FINLANDE

RECEIVED
02. 03. 2001
PATENTTITOIMISTO

Date of mailing (day/month/year) 19 February 2001 (19.02.01)	
Applicant's or agent's file reference OP100021/JUM	**IMPORTANT NOTIFICATION**
International application No. PCT/FI00/00635	**International filing date** (day/month/year) 10 July 2000 (10.07.00)

1. The following indications appeared on record concerning:

☐ the applicant ☐ the inventor ☒ the agent ☐ the common representative

Name and Address

BERGGREN OY AB
P.O. Box 16
FIN-00101 Helsinki
Finland

State of Nationality:
State of Residence:
Telephone No.: +358-9-693701
Facsimile No.: +358-9-6933944
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☒ the name ☒ the address ☐ the nationality ☐ the residence

Name and Address

OULUN PATENTTITOIMISTO
Berggren Oy AB
Teknologiantie 14 D
FIN-90570 Oulu
Finland

State of Nationality:
State of Residence:
Telephone No.: +358 8 511 5670
Facsimile No.: +358 8 556 6701
Teleprinter No.:

3. Further observations, if necessary:
Please also not the change of file reference number.

4. A copy of this notification has been sent to:

☒ the receiving Office
☐ the International Searching Authority
☒ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Marie-José Devillard Telephone No.: (41-22) 338.83.38

Form PCT/IB/306 (March 1994)

003846482

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

OULUN PATENTTITOIMISTO
Berggren Oy AB
Teknologiantie 14 D
FIN-90570 Oulu
FINLANDE

RECEIVED
19. 11. 20
OULUN PATENTTITOIM.

Date of mailing (day/month/year) 09 November 2001 (09.11.01)	
Applicant's or agent's file reference OP100021/JUM	**IMPORTANT NOTIFICATION**
International application No. PCT/FI00/00635	**International filing date** (day/month/year) 10 July 2000 (10.07.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
NOKIA NETWORKS OY P.O. Box 300 FIN-00045 Nokia Group Finland	FI	FI
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
NOKIA CORPORATION Keilalahdentie 4 FIN-02150 Espoo Finland	FI	FI
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Marie-José DEVILLARD
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY 10/030502

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

OULUN PATENTTITOIMISTO
Berggren Oy AB
Teknologiantie 14 D
FIN-90570 Oulu
FINLANDE

Date of mailing (day/month/year) 19 February 2001 (19.02.01)	
Applicant's or agent's file reference OP100021/JUM	**IMPORTANT INFORMATION**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/FI00/00635	10 July 2000 (10.07.00)	09 July 1999 (09.07.99)

Applicant
NOKIA NETWORKS OY et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZW
   EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
   National :AE,AG,AL,AM,AT,AZ,BA,BB,BR,BY,BZ,CH,CR,CU,DK,DM,DZ,EE,ES,FI,GB,
   GD,GE,GH,GM,HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MW,
   MX,MZ,PT,SD,SG,SI,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:
Marie-José Devillard

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

10/030502

PCT

From the INTERNATIONAL BUREAU

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

BERGGREN OY AB
P.O. Box 16
FIN-00101 Helsinki
FINLANDE

Date of mailing (day/month/year)
30 November 2000 (30.11.00)

Applicant's or agent's file reference
50065 OP100021

IMPORTANT NOTIFICATION

International application No.
PCT/FI00/00635

International filing date (day/month/year)
10 July 2000 (10.07.00)

International publication date (day/month/year)
Not yet published

Priority date (day/month/year)
09 July 1999 (09.07.99)

Applicant
NOKIA NETWORKS OY et al

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.
3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
09 July 1999 (09.07.99)	991585	FI	06 Octo 2000 (06.10.00)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

J. Leitao

Telephone No. (41-22) 338.83.38

10/030502 WO 01/04986
PCT/FI00/00635

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
BERGGREN OY AB
P.O. Box 16
FIN-00101 Helsinki
FINLANDE

RECEIVED
26. 01. 2001
OULUN PATENTTITOIMISTO
Berggren Oy Ab
25 -01- 2001
OULU

Date of mailing (day/month/year)	
18 January 2001 (18.01.01)	
Applicant's or agent's file reference 50065 6P10002	**IMPORTANT NOTICE**

International application No.	International filing date (day/month/year)	Priority date (day/month/year)
PCT/FI00/00635	10 July 2000 (10.07.00)	09 July 1999 (09.07.99)

Applicant
NOKIA NETWORKS OY et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AG,AU,BZ,DZ,KP,KR,MZ,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EA,EE,EP,ES,FI,GB,GD, GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX, NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   18 January 2001 (18.01.01) under No. WO 01/04986

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

RECORD COPY

PCT REQUEST

50065

Original (for **SUBMISSION**) - printed on 10.07.2000 09:54:33 AM

0 0-1	**For receiving Office us nly** International Application No.	PCT/FI 0 0 / 0 0 6 3 5
0-2	International Filing Date	1 0 JUL 2000 (1 0 -07- 2000)
0-3	Name of receiving Office and "PCT International Application"	The Finnish Patent Office PCT International Application
0-4 0-4-1	**Form - PCT/RO/101 PCT Request** Prepared using	**PCT-EASY Version 2.90 (updated 10.05.2000)**
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	**National Board of Patents and Registration (Finland) (RO/FI)**
0-7	**Applicant's or agent's file reference**	**50065**
I	**Title of invention**	**METHOD FOR CREATING WAVEGUIDES IN MULTILAYER CERAMIC STRUCTURES AND A WAVEGUIDE**
II	**Applicant**	
II-1	This person is:	**applicant only**
II-2	Applicant for	**all designated States except US**
II-4	Name	**NOKIA NETWORKS OY**
II-5	Address:	**P.O. Box 300 FIN-00045 Nokia Group Finland**
II-6	State of nationality	**FI**
II-7	State of residence	**FI**
II-8	Telephone No.	**+358-9-51121**
II-9	Facsimile No.	**+358-9-51168080**
III-1	**Applicant and/or inventor**	
III-1-1	This person is:	**applicant and inventor**
III-1-2	Applicant for	**US only**
III-1-4	Name (LAST, First)	**SALMELA, Olli**
III-1-5	Address:	**Haahkakuja 1 D 41 FIN-00200 Helsinki Finland**
III-1-6	State of nationality	**FI**
III-1-7	State of residence	**FI**

PCT REQUEST

50065

Original (for **SUBMISSION**) - printed on 10.07.2000 09:54:33 AM

III-2	**Applicant and/ r invent r**	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	KEMPPINEN, Esa
III-2-5	Address:	Vermonrinne 17 A FIN-00370 Helsinki Finland
III-2-6	State of nationality	FI
III-2-7	State of residence	FI
III-3	**Applicant and/or inventor**	
III-3-1	This person is:	applicant and inventor
III-3-2	Applicant for	US only
III-3-4	Name (LAST, First)	SOMERMA, Hans
III-3-5	Address:	Mäkeläntie 1 FIN-02880 Veikkola Finland
III-3-6	State of nationality	FI
III-3-7	State of residence	FI
III-4	**Applicant and/or inventor**	
III-4-1	This person is:	applicant and inventor
III-4-2	Applicant for	US only
III-4-4	Name (LAST, First)	IKÄLÄINEN, Pertti
III-4-5	Address:	Pähkinälehto 27 FIN-03150 Huhmari Finland
III-4-6	State of nationality	FI
III-4-7	State of residence	FI
III-5	**Applicant and/or inventor**	
III-5-1	This person is:	applicant and inventor
III-5-2	Applicant for	US only
III-5-4	Name (LAST, First)	KOIVISTO, Markku
III-5-5	Address:	Niittykatu 3 C 41 FIN-02200 Espoo Finland
III-5-6	State of nationality	FI
III-5-7	State of residence	FI
IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name	BERGGREN OY AB
IV-1-2	Address:	P.O. Box 16 FIN-00101 Helsinki Finland
IV-1-3	Telephone No.	+358-9-693701
IV-1-4	Facsimile No.	+358-9-6933944
IV-1-5	e-mail	email.box@berggren.fi

PCT REQUEST

50065

Original (for **SUBMISSION**) - printed on 10.07.2000 09:54:33 AM

V	**Designati n f States**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	**AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT** **EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT** **EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT** **OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT**
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	**AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW**
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	**Exclusion(s) from precautionary designations**	**NONE**
VI-1	**Priority claim of earlier national application**	
VI-1-1	Filing date	**09 July 1999 (09.07.1999)**
VI-1-2	Number	**991585**
VI-1-3	Country	**FI**
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	**VI-1**

PCT REQUEST

50065

Original (for **SUBMISSION**) - printed on 10.07.2000 09:54:33 AM

VII-1	Internati nal Searching Authority Ch s n	Swedish Patent Offic (ISA/SE)	
VIII	**Check list**	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	10	-
VIII-3	Claims	3	-
VIII-4	Abstract	1	50065.txt
VIII-5	Drawings	4	-
VIII-7	TOTAL	22	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-9	Separate signed power of attorney	✓	-
VIII-10	Copy of general power of attorney	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-17	Other (specified):	Copy of Official Action in FI 991585	-
VIII-18	**Figure of the drawings which should accompany the abstract**	3	
VIII-19	**Language of filing of the international application**	Finnish	
IX-1	**Signature of applicant or agent**		
IX-1-1	Name	BERGGREN OY AB	
IX-1-2	Name of signatory	Markus Levlin	
IX-1-3	Capacity	Patent Attorney	

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	10 JUL 2000 (10 -07- 2000)
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/SE
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	14 AUGUST 2000 (14.08.00)

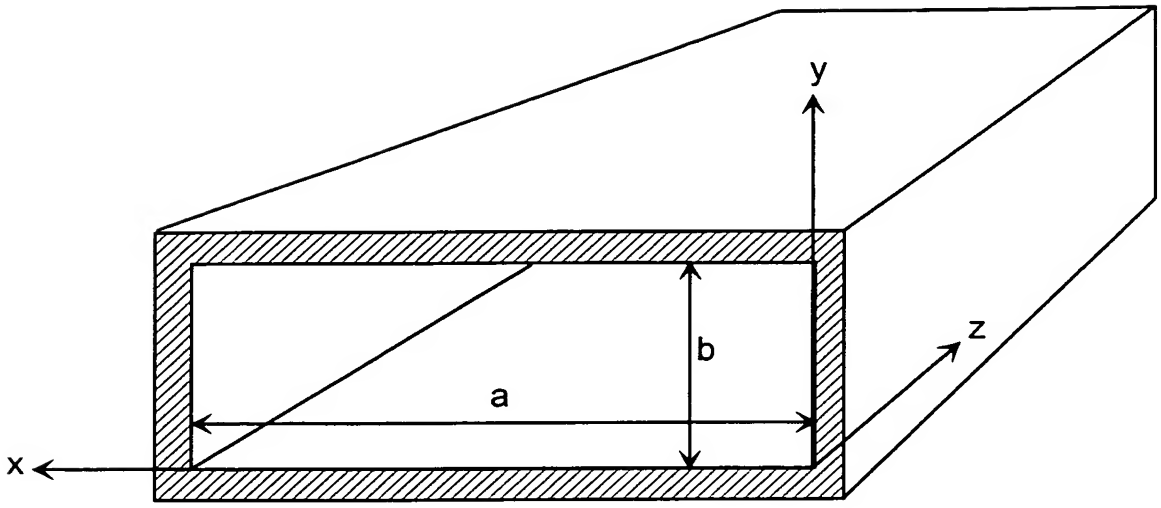

Fig. 1

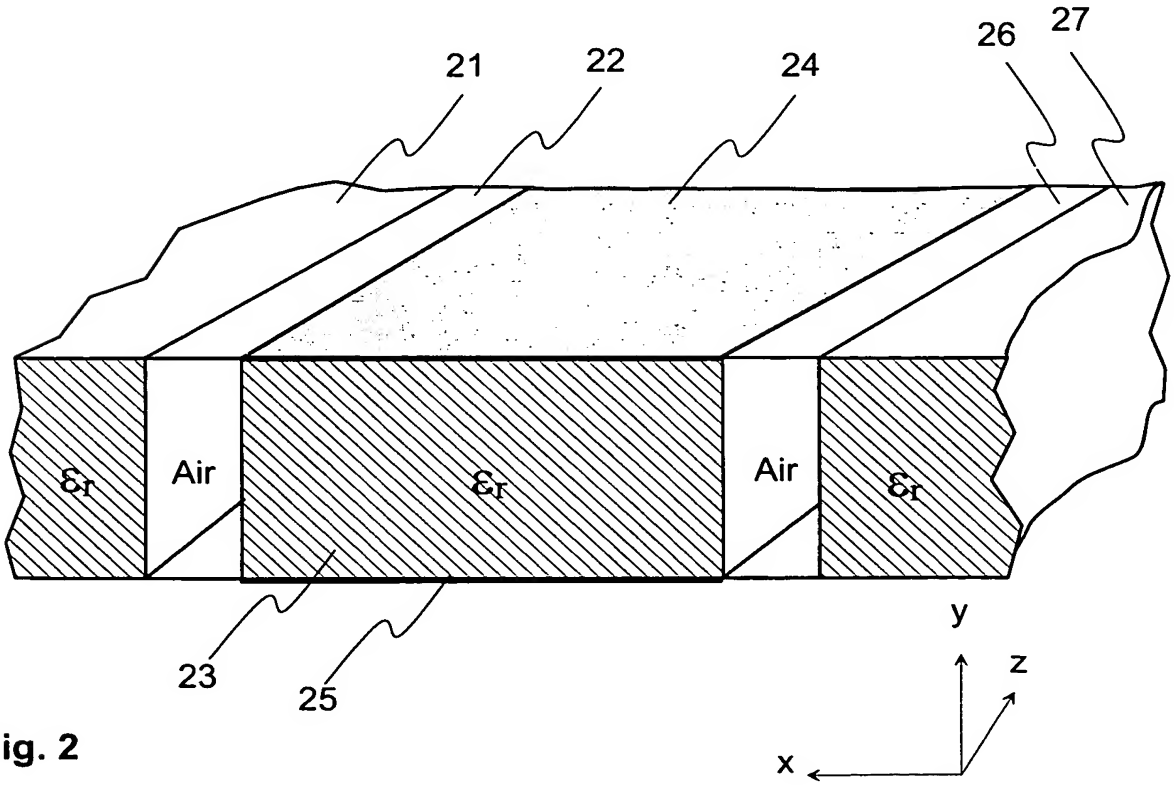

Fig. 2

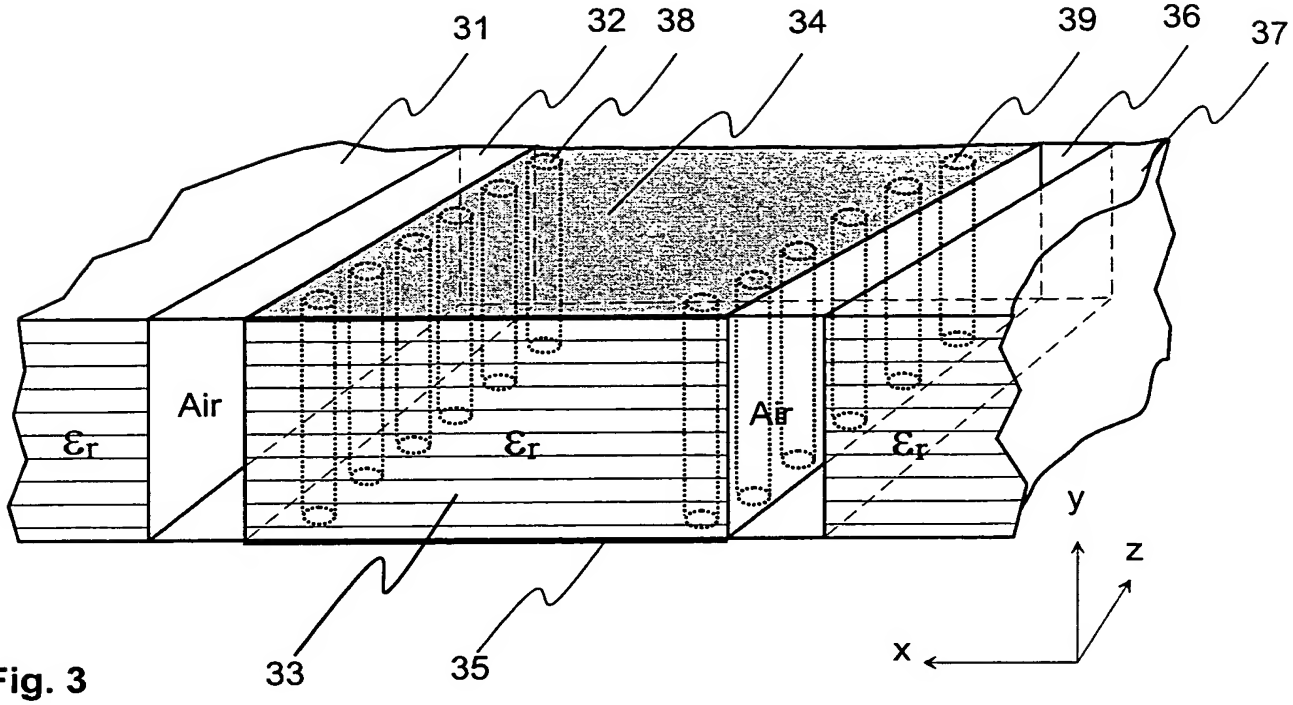
31
32
38
34
39
36
37
Air
ε_r
ε_r
Air
ε_r
y
z
x
33
35

Fig. 3

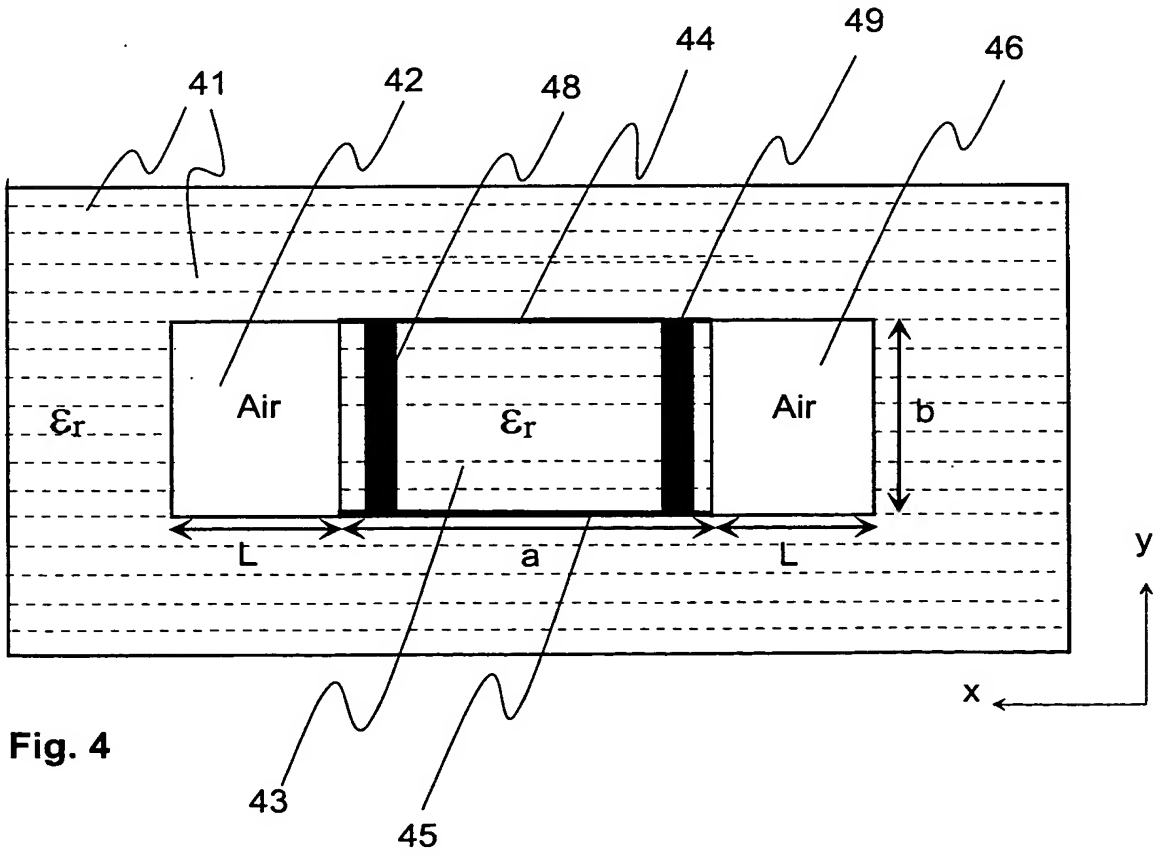
41
42
48
44
49
46
Air
ε_r
ε_r
Air
b
L
a
L
y
x
43
45

Fig. 4

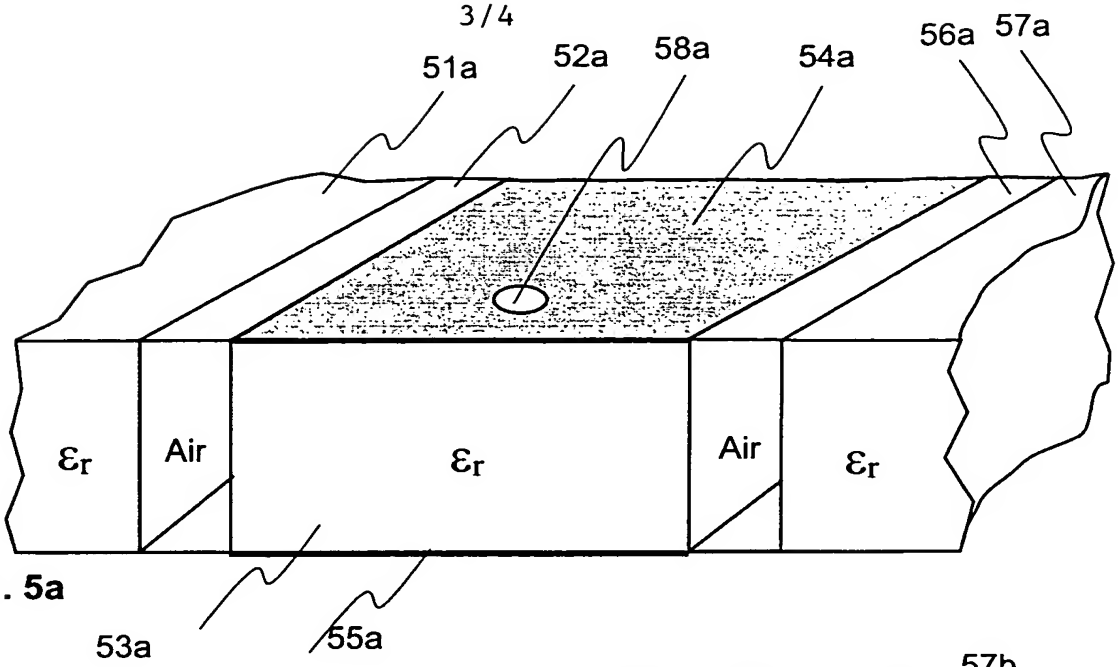

Fig. 5a

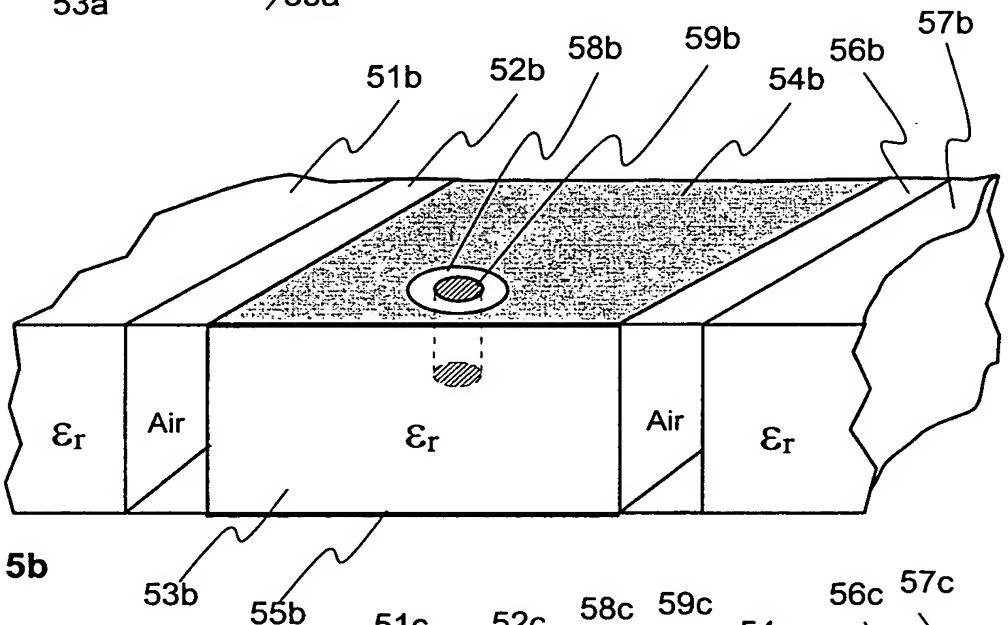

Fig. 5b

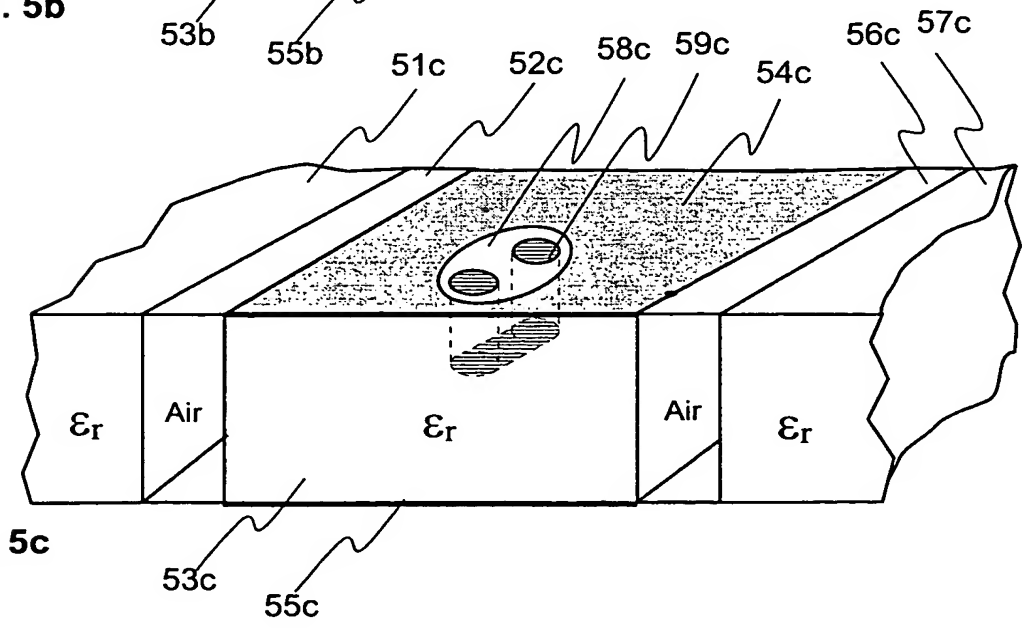

Fig. 5c

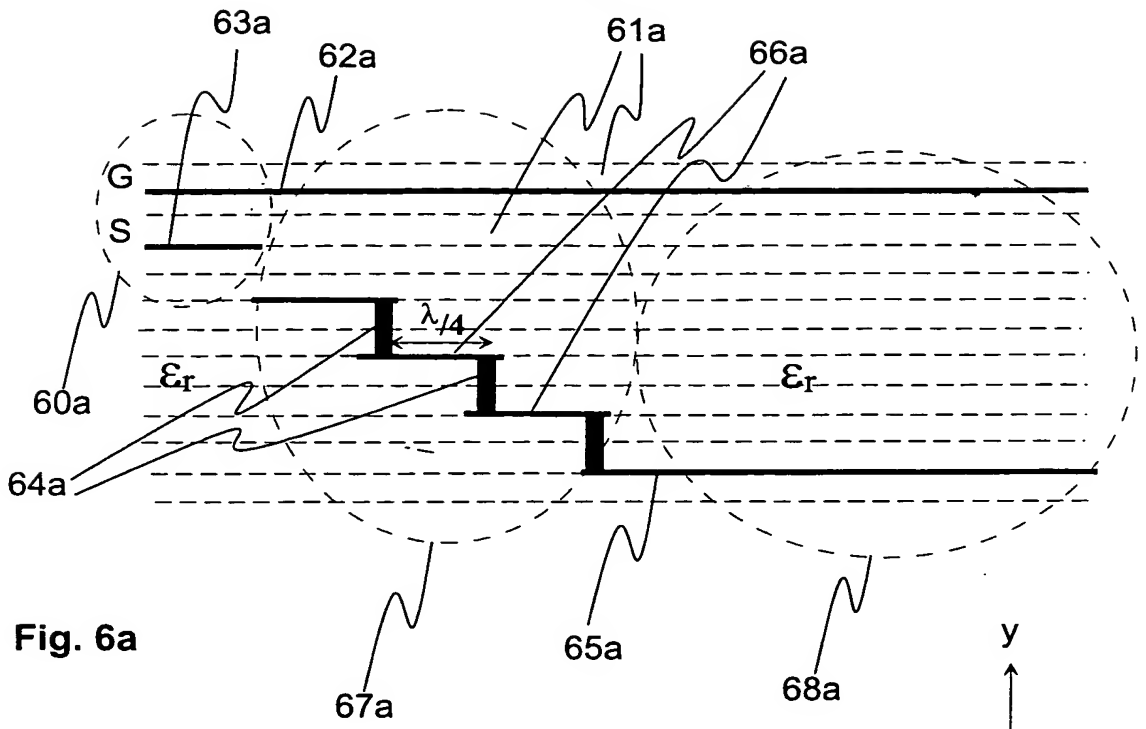
63a
62a
61a
66a
G
S
λ/4
εr
εr
60a
64a
67a
65a
68a
y
z

Fig. 6a

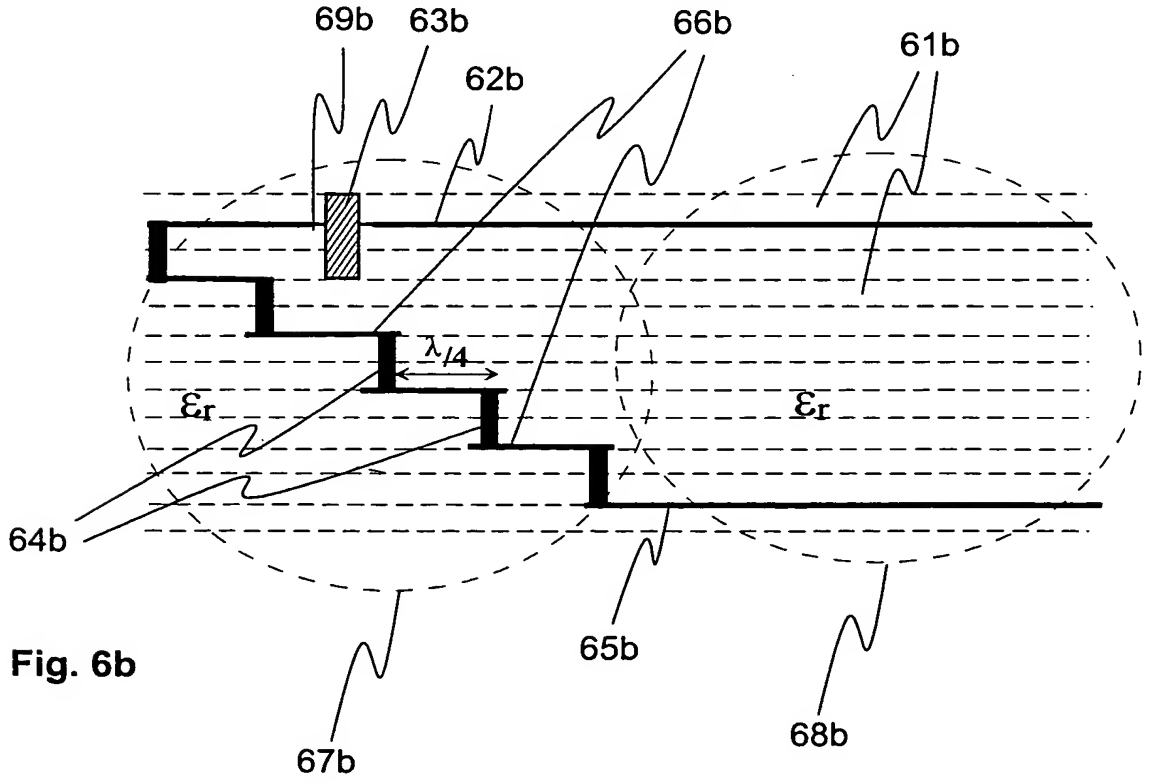
69b
63b
62b
66b
61b
λ/4
εr
εr
64b
67b
65b
68b

Fig. 6b

Menetelmä aaltojohdon toteuttamiseksi monikerroskeramiikkarakenteissa ja aaltojohto

Keksinnön kohteena on menetelmä aaltojohdon valmistamiseksi monikerroskeramiikalla valmistettaviin piirikokonaisuuksiin, jonka piirikokonaisuuden mitat ja rakennesuunnat ovat määriteltävissä toisiaan vastaan kohtisuorien x-, y- ja z-akselien avulla, ja jossa valmistusmenetelmässä piirikokonaisuus kootaan erillisistä keraamisista kerroksista, joiden kerrosten permittiivisyys ε_r on ilman vastaavaa arvoa suurempi ja joihin kerroksiin voidaan tehdä halutun muotoisia onteloita ja reikiä sekä jonka keraamisen kerroksen pinnalle voidaan silkkipainaa haluttuun kohtaan halutun muotoinen johtava materiaalikerros ja joka piirikokonaisuus saatetaan valmiiksi saattamalla piirikokonaisuus korkeaan lämpötilaan.

Keksinnön kohteena on myös monikerroskeramiikalla valmistettaviin piirikokonaisuuksiin integroitu aaltojohto, jonka piirikokonaisuuden mitat ja rakennesuunnat ovat määriteltävissä toisiaan vastaan kohtisuorien x-, y- ja z-akselien avulla, ja jossa piirikokonaisuus on kootu erillisistä keraamisista kerroksista, joiden kerrosten permittiivisyys ε_r on ilman vastaavaa arvoa suurempi ja joihin kerroksiin on valmistettu halutun muotoisia onkaloita ja reikiä ja jonka keraamisen kerroksen pinnalle on silkkipainettavissa haluttuun kohtaan halutun muotoinen johtava materiaalikerros.

Elektronisten laitteiden rakenteissa käytetään hyväksi erilaisia johtorakenteita. Mitä suurempia taajuuksia laitteissa käytetään, sitä suurempia vaatimuksia asetetaan käytettäville johtorakenteille, jotta johtorakenteiden aiheuttama vaimennus ei kasva liian suureksi tai ettei käytetty johtorakenne säteilemällä häiritse muita laitteeseen kuuluvia osia. Laitteen suunnittelijalla on valittavana useita mahdollisia johtorakenteita. Sovelluksesta riippuen voidaan käyttää esim. metallista valmistettua, ilmatäytteistä aaltoputkea, jonka periaatteellinen rakenne, mitoitus, aaltoputkessa etenemään kykenevät aaltomuodot ja aaltoputken taajuusominaisuudet tunnetaan hyvin (esim luku 8 Fields and Waves in Communication Electronics, Simon Ramo et al., John Wiley & Sons, inc., USA). Kuvassa 1 on esimerkkinä aaltoputken mitoitustavasta esitetty nelikulmainen, johtavasta materiaalista muodostettu aaltoputki, jonka leveys on kuvassa esitetyn koordinaatiston x-akselin suuntaan a, korkeus y-akselin suuntaan b ja se on ilmatäytteinen, jolloin sen permittiivisyys ε_r on luokkaa 1. Kuvan 1 esittämässä ilmatäytteisessä aaltoputkessa ensimmäinen (alin) kuvan z-akselin suuntaan etenemään pystyvä aaltomuoto on ns. TE_{10}-aalto-

muoto (Transverse-electric). Kyseisen aaltomuodon sähkökentällä E ei ole lainkaan z-akselin suuntaista komponenttia. Sen sijaan magneettikentällä H on etenemissuuntaan, z-akselin suuntaan, oleva komponentti. TE_{10}-aaltomuodon ns. katkaisutaajuus f_c, jolla tarkoitetaan alinta aaltoputkessa etenemään pystyvää taajuutta, saadaan yhtälöstä:

$$f_{cTE_{10}} = c/2a$$

jossa a tarkoittaa aaltoputken leveyttä a x-akselin suuntaan ja c on valon nopeus tyhjiössä. Yleensä aaltoputken käyttökelpoinen taajuusalue on 1,2-1,9 kertaa kyseisen aaltomuodon katkaisutaajuus. Käyttökelpoisen alarajataajuuden määrää vaimennuksen kasvu lähestyttäessä ylhäältäpäin katkaisutaajuutta f_c. Ylärajataajuuden puolestaan määrää se, että taajuuksilla, jotka ovat yli kaksinkertaisia halutun aaltomuodon katkaisutaajuuteen f_c verrattuna, aaltoputkeen syntyy myös muita etenemään kykeneviä aaltomuotoja, joiden syntyminen halutaan välttää.

Tunnetaan myöskin aaltoputkirakenteita, joissa aaltoputken muodostaa eristeaineesta koostuva sydänosa, joka on päällystetty ohuella johtavasta aineesta valmistetulla materiaalikerroksella. Kyseiset aaltoputket kuitenkin valmistetaan aina erilliskomponenteiksi. Edellä kuvatuilla aaltoputkirakenteilla päästään pieneen vaimennukseen pituusyksikköä kohden, ja ne eivät juurikaan säteile ympäristöönsä häiriösäteilyä. Niiden ongelmana on kuitenkin kyseisten aaltoputkien suuri fyysinen koko muuhun valmistettavaan piirikokonaisuuteen verrattuna sekä se, että niiden valmistuksen integroitavuus muuhun piirikokonaisuuden valmistukseen on vaikeaa. Kyseiset aaltoputket joudutaan liittämään mekaanisesti joko juottamalla tai jollain muulla mekaanisella liitoksella piirikokonaisuuteen omassa erillisessä työvaiheessaan, mikä aiheuttaa ylimääräistä vikaantumisen vaaraa ja lisäkustannuksia.

Elektronisissa laitteissa käytetään myöskin hyväksi paremmin rakenteeseen integroituja johtorakenteita. Niitä ovat mm. liuskajohto, mikroliuskajohto ja koplanaariset johdot. Niiden valmistus voidaan integroida muun valmistettavan piirikokonaisuuden yhteyteen tehtäessä piirikokonaisuuksia keraamisina rakenteina. Tätä valmistustekniikkaa kutsutaan monikerroskeramiikkatekniikaksi ja se perustuu joko HTCC-tekniikkaan (High Temperature Cofired Ceramics) tai LTCC-tekniikkaan (Low Temperature Cofired Ceramics). Molemmilla valmistustekniikoilla toteutetut piirirakenteet koostuvat useasta noin 100 µm:n paksuisesta keraamisesta materiaalikerroksesta (engl. green tape), jotka piirirakennetta koottaessa asetetaan päällekkäin. Ennen loppukäsittelynä tehtävää lämpökäsittelyä käytetty keraaminen mate-

riaali on vielä pehmeää, joten keraamisiin kerroksiin voidaan tehdä halutun muotoisia onkaloita ja läpivientireikiä. Samoin haluttuihin kohtiin voidaan silkkipainomenetelmällä valmistaa erilaisia sähköisesti passiivisia elementtejä ja yllä mainittuja johtimia. Kun haluttu piirikokonaisuus on saatu rakenteellisesti valmiiksi, keraaminen monikerrosrakenne poltetaan sopivassa lämpötilassa. LTCC-tekniikassa käytetty lämpötila on luokkaa 850 °C ja HTCC-tekniikassa luokkaa 1600 °C. LTCC- ja HTCC-tekniikoilla valmistettujen mikroliuskajohtojen, liuskajohtojen ja koplanaaristen johtojen ongelmana on kuitenkin niiden suuri vaimennus pituusyksikköä kohden, heikko tehonsieto ja myöskin niiden varsin huono EMC-suojaus (ElectroMagnetic Compatibility). Nämä ongelmat rajoittavat kyseisten johtorakenteiden käyttöä niissä kohteissa, joissa edellä mainittuja ominaisuuksia tarvitaan.

Keksinnön tarkoituksena on aikaansaada monikerroskeramiikkatekniikalla toteutettava aaltojohtorakenne, jolla voidaan vähentää mainittuja, tekniikan tason mukaisiin johtorakenteisiin liittyviä haittoja.

Keksinnön mukaiselle menetelmälle on tunnusomaista, että z-akselin suuntaisen aaltojohdon muodostamiseksi:
- rakenteeseen muodostetaan ainakin kaksi rakenteen yz-tason suuntaista aaltojohdon pituista impedanssin muutoskohtaa, joilla impedanssin muutoskohdilla rajataan x-akselin suunnassa aaltojohdon ytimen mitta a, ja
- että xz-tasossa aaltojohdon ydin rajataan ensimmäisellä ja toisella kerroksella johtavaa materiaalia, jotka on silkkipainettu aaltojohdon ytimen muodostavien keraamisten kerrosten päälle, ja joilla johtavilla tasoilla rajataan y-akselin suunnassa aaltojohdon ytimen mitta b.

Keksinnön mukaiselle aaltojohdolle on tunnusomaista, että aaltojohto käsittää:
- piirikokonaisuuden rakenteen z-akselin suuntaisen aaltojohdon ydinosan,
- ainakin kaksi yz-tasossa sijaitsevaa impedanssin epäjatkuvuuskohtaa, joilla on rajattu aaltojohdon ydinosan mitta a x-akselin suunnassa, sekä
- xz-tasossa sijaitsevat ensimmäisen ja toisen kerroksen johtavaa materiaalia, joilla kerroksilla on rajattu aaltojohdon ydinosan mitta b y-akselin suunnassa.

Keksinnön eräitä edullisia suoritusmuotoja on esitetty epäitsenäisissä patenttivaatimuksissa.

Keksinnön perusajatus on seuraava: Monikerroskeramiikkatekniikalla valmistetaan rakenteeseen täysin integroitu aaltojohto, jonka ydinosa muodostuu permittiivisyydeltään ε_r sopivasta eristeestä, joka on erotettu muusta keraamisesta rakenteesta

yhdessä tasossa kahdella samansuuntaisella johtavasta aineesta muodostetulla tasomaisella kerroksella ja toisessa tasossa, joka on edellisiä tasoja vastaan kohtisuora taso, kahdella ilmatäytteisellä onkalolla ja/tai johtavalla materiaalilla täytetyillä yhdistysrei'illä.

Keksinnön etuna on, että aaltojohto voidaan valmistaa samanaikaisesti muiden monikerroskeramiikkatekniikalla valmistettavien komponenttien kanssa.

Lisäksi keksinnön etuna on, että aaltojohdon syöttöjärjestely voidaan toteuttaa saman monikerroskeramiikkatekniikan avulla.

Edelleen keksinnön etuna on, että menetelmällä valmistettu aaltojohto on edullisempi valmistaa kuin erilliskomponenteista valmistettu ja kokonaisuuteen erillisessä työvaiheessa liitetty aaltoputki.

Edelleen keksinnön etuna on hyvä EMC-suojaus verrattuna liuskajohtoon, mikroliuskajohtoon tai koplanaarijohtoon.

Seuraavassa keksintöä selostetaan yksityiskohtaisesti. Selostuksessa viitataan oheisiin piirustuksiin, joissa

kuva 1 esittää ilmatäytteistä, johtavasta materiaalista valmistettua tavanomaista aaltoputkea,

kuva 2 esittää esimerkinomaisesti monikerroskeramiikkatekniikalla toteutettua suoritusmuotoa, jossa aaltojohdon sivuseinämät muodostuvat ilmatäytteisistä onkaloista,

kuva 3 esittää esimerkinomaisesti monikerroskeramiikkatekniikalla toteutettua toista suoritusmuotoa, jossa aaltojohdon sivuseinämät muodostuvat ilmatäytteisistä onkaloista ja niiden läheisyydessä olevista johtavalla materiaalilla täytetyistä läpivientirei'istä,

kuva 4 esittää esimerkinomaisesti monikerroskeramiikkatekniikalla toteutettua keksinnön toisen suoritusmuodon mukaista aaltojohtoa x-y-tason leikkauskuvana,

kuva 5a esittää esimerkinomaisesti yhtä keksinnön mukaista tapaa herättää etenemään pystyvä aaltomuoto ensimmäisen suoritusmuodon mukaiseen aaltojohtoon,

kuva 5b esittää esimerkinomaisesti erästä toista keksinnön mukaista tapaa herättää etenemään pystyvä aaltomuoto ensimmäisen suoritusmuodon mukaiseen aaltojohtoon,

kuva 5c esittää esimerkinomaisesti erästä kolmatta keksinnön mukaista tapaa herättää etenemään pystyvä aaltomuoto ensimmäisen suoritusmuodon mukaiseen aaltojohtoon,

kuva 6a esittää yz-tason kuvantona erästä tapaa keksinnön mukaisen suoritusmuodon mukaisen aaltojohdon liittämiseksi mikroliuskajohtoon ja

kuva 6b esittää yz-tason kuvantona keksinnön mukaisen suoritusmuodon mukaisen aaltojohdon syöttöpisteen sovittamista aaltojohtoon.

Kuva 1 on esitetty tekniikan tason kuvauksen yhteydessä. Kuvien 2-6 selityksen yhteydessä viitataan kuvassa 1 esitettyihin x-, y- ja z-akselien suuntiin. Kyseiset akselien suunnat ovat samat kuin kuvan 1 esimerkissä esitetyt, vaikka kyseisiä akseleita ei ole kaikkiin kuviin piirretty.

Kuvassa 2 on esitetty esimerkinomaisesti keksinnön ensimmäisen suoritusmuodon mukainen monikerroskeramiikkatekniikalla toteutettu aaltojohto. Kuvan 2 esittämä rakenne kuuluu osana suurempaan monikerroskeramiikkatekniikalla toteutettuun piirirakenteeseen, jota ei ole kuvassa kaikilta osin esitetty. Aaltojohtorakennetta ympäröi molemmilta puolin kuvassa esitetyt useista keraamisista kerroksista (engl. green tape) koostuvat rakenteet 21 ja 27. Niissä käytetyn keraamisen materiaalin permittiivisyys ε_r on selvästi suurempi kuin ilman permittiivisyys, joka on tunnetusti suuruusluokaltaan 1. Samasta keraamisesta materiaalista koostuvat pääosin muut rakenteen osat, joita on myös kuvassa esitetyn aaltojohtorakenteen sekä yläettä alapuolella y-akselin suuntaan katsottuna. Aaltojohdon ydinosan 23 muodostaa sama keraaminen aines kuin mitä muun piirirakenteen muodostama materiaali on. Aaltojohdon leveyden x-akselin suuntaan rajaavat oleellisesti yz-tason suuntaiset, ilmatäytteiset onkalot 22 ja 26. Ilmatäytteisen onkalon 22 tai 26 rajapinta muodostaa ydinosaa 23 vastaan sähkömagneettisen aaltorintaman kannalta aaltoimpedanssin epäjatkuvuuskohdan. Tämä aaltoimpedanssin epäjatkuvuuskohta heijastaa pääosin aaltojohdon ydinosassa 23 etenemään pystyvän aaltorintaman takaisin ydin-osaan 23 aaltorintaman edetessä z-akselin suuntaan. Aaltojohdon rajaa xz-tasossa jostain johtavasta materiaalista tehdyt oleellisesti yhdensuuntaiset tasomaiset ensimmäinen pinta 24 ja toinen pinta 25. Kyseiset tasomaiset pinnat 24 ja 25 voidaan tehdä joko täysin ydinosan 23 peittäviksi tai osittain verkkomaisiksi. Ky-

seiset tasomaiset, johtavat pinnat 24 ja 25 voidaan valmistaa esimerkiksi johtavasta pastamaisesta materiaalista, metalloimalla ydinosan 23 pinnat kyseisissä tasoissa tai myöskin peittämällä ydinosa 23 erillisellä, ohuella johtavalla kalvomaisella materiaalilla.

Keksinnön ensimmäisen suoritusmuodon mukaisessa aaltojohdossa etenee alimpana mahdollisena etenemismuotona ns. TEM-aaltomuoto (Transverse-electromagnetic), jonka sähkökentällä tai magneettikentällä ei ole kuvan z-akselin suuntaan olevaa komponenttia. Kyseisen aaltomuodon katkotaajuus on tunnetusti 0 Hz eli kyseisessä aaltojohdossa voi kulkea tasavirta. Keksinnön ensimmäisen suoritusmuodon mukainen aaltojohto kykenee siirtämään myös muita korkeampia mahdollisesti haluttuja TE_{mn}- tai TM_{mn}-aaltomuotoja (Transverse-magnetic), joiden vastaavat katkotaajuudet voidaan laskea tavanomaisen aaltoputken mitoitussääntöjen mukaisesti, jotka mitoitussäännöt on esitetty kuvan 4 selityksen yhteydessä.

Kuvassa 3 on esitetty esimerkinomaisesti keksinnön toisen suoritusmuodon mukainen aaltojohto. Kuvan 3 esittämä rakenne kuuluu osana suurempaan monikerroskeramiikkatekniikalla toteutettuun rakenteeseen, jota ei ole kuvassa kaikilta osin esitetty. Aaltojohtorakennetta ympäröi molemmilta puolin kuvassa esitetyt useista keraamisista kerroksista (engl. green tape) koostuvat rakenteet 31 ja 37. Niissä käytetyn keraamisen materiaalin permittiivisyys ε_r on selvästi suurempi kuin ilman permittiivisyys, joka on suuruusluokaltaan 1. Samasta keraamisesta materiaalista koostuvat pääosin myös muut rakenteen osat, joita on kuvassa esitetyn aaltojohtorakenteen sekä ylä- että alapuolella kuvan y-akselin suuntaan katsottuna. Aaltojohdon ydinosan 33 muodostaa sama keraaminen aines kuin mitä muun piirirakenteen muodostama materiaali on. Aaltojohdon leveyden x-akselin suuntaan rajaavat kaksi, kuvan z-akselin suuntaista, oleellisesti yhdensuuntaista impedanssin epäjatkuvuuskohtaa, jotka muodostuvat yhdessä kuvan y-akselin suuntaisista läpivientireikäriveistä (engl. via posts) 38 ja 39 sekä ilmatäytteisistä onkaloista 32 ja 36. Kyseiset ilmatäytteiset onkalot 32 ja 36 ovat rakenteeltaan vastaavanlaiset kuin mitä kuvan 2 yhteydessä olevien onkaloiden kuvauksen yhteydessä on esitetty. Läpivientireikärivit 38, 39 täytetään johtavalla, pastamaisella materiaalilla piirirakenteen valmistamisen yhteydessä. Käytettäessä LTCC-tekniikkaa voidaan edullisesti käyttää joko AgPd-pastaa tai Ag-pastaa. Mikäli keksinnön mukainen aaltojohtorakenne ympäröidään täysin joka puolelta muilla keraamisilla kerroksilla, voidaan käyttää halvempaa Ag-pastaa. Jos osa syntyvästä aaltojohtorakenteesta jää ulkoiselle atmosfäärille alttiiksi, joudutaan käyttämään kalliimpaa AgPd-pastaa. Läpivientireikärivit 38, 39 yhdistävät ydinosan 33 xz-tasossa rajaavat, johtavasta mate-

riaalista muodostetut, oleellisesti yhdensuuntaiset ensimmäisen tason 34 ja toisen tason 35.

Kuvassa 3 esitetyssä suoritusmuodossa on kuvaan piirretty yksi läpivientirivistö 38 ja 39 kummallekin ydinosan 33 sivulle x-akselin suunnassa katsottuna. Keksinnön mukaista aaltojohtorakennetta voidaan soveltaa myöskin lisäämällä useampia vastaavanlaisia rivistöjä ydinosaan 33. On myös mahdollista sijoittaa vastaavanlaisia läpivientirivistöjä lisää ilmaonkaloiden 32 ja 36 taakse jääviin piirirakenteen osiin 31 ja 36, jolla menettelyllä parannetaan aaltojohdon EMC-ominaisuuksia edelleen.

Kuvassa 4 on esimerkinomaisesti esitetty keksinnön toisen suoritusmuodon mukainen rakenne xy-tason leikkauskuvana. Keraaminen piirirakenne kootaan kerroksittain keraamisista levyistä/nauhoista 41. Aaltojohdon erottavat muusta rakenteesta x-akselin suunnassa yz- tason suuntaiset ilmatäytteiset onkalot 42 ja 46, joiden onkaloiden leveys on kuvassa esitetty mitta L ja korkeus kuvassa esitetty mitta b, sekä johtavalla materiaalilla täytetyt läpivientireikärivistöt 48 ja 49. Aaltojohdon ydinosan 43 muodostaa keraaminen aines, jonka permittiivisyys ε_r on suuri ilmaan verrattuna. Aaltojohdon ydinosan leveyttä x-akselin suuntaan on kuvassa merkitty kirjaimella a. Ilmatäytteisten onkaloiden 42 ja 46 x-tasossa oleva leveysmitta L valitaan suuruudeltaan vastaamaan katkotaajuuden f_c aallonpituuden neljäsosaa. Tällöin aaltojohtorakenne säteilee mahdollisimman vähän häiriösäteilyä ympäristöönsä. Kuvan 4 esittämää pintaa vastaan kohtisuorassa xz-tasossa aaltojohdon rajaavat johtavasta materiaalista muodostetut oleellisesti yhdensuuntaiset ensimmäinen taso 44 ja toinen taso 45. Ensimmäinen taso 44 ja toinen taso 45 on yhdistetty toisiinsa johtavalla materiaalilla täytetyillä läpivientirei'illä 48 ja 49. Kuvassa esitetyn suoritusmuodon mukaisessa aaltojohdossa voivat edetä aaltomuodot TE_{mn} ja TM_{mn}, joiden katkotaajuudet f_{cmn} saadaan sinällään ennestään tunnetusta kaavasta:

$$f_{cm,n} = \frac{1}{2\sqrt{\mu\,\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

Kaavassa indeksit m ja n viittaavat aaltomuodon TE_{mn} tai TM_{mn} poikittaisen kenttäjakauman x- ja y-akselien suunnassa olevien maksimien lukumäärään, mitta a esittää aaltojohdon leveyttä x-akselin suuntaan ja mitta b esittää aaltojohdon korkeutta y-akselin suuntaan. Kaavassa esiintyvät termit μ ja ε ovat aaltojohdon ydinosan 43 muodostaman keraamisen materiaalin permeabiliteetti- ja permittiivisyysarvot.

Kuvissa 5a, 5b ja 5c on esitetty kolme erilaista esimerkkiä siitä, millä tavoin haluttu aaltomuoto voidaan herättää keksinnön mukaisissa aaltojohdoissa. Kuvien esimerkeissä aaltojohtona on käytetty ensimmäisen suoritusmuodon mukaista aaltojohtoa, mutta ratkaisut toimivat saman periaatteen mukaisesti myöskin keksinnön toisen suoritusmuodon mukaisissa aaltojohtorakenteissa.

Kuvan 5a esimerkissä aaltojohdon ytimen 53a erottaa muusta piirirakenteesta, jota kuvassa esittävät rakenteen osat 51a ja 57a, ilmatäytteiset onkalot 52a ja 56a sekä johtavasta materiaalista muodostetut oleellisesti yhdensuuntaiset ensimmäinen taso 54a ja toinen taso 55a. Halutun aaltomuodon herättämiseksi on muodostetussa aaltojohdossa ensimmäiseen tasoon 54a tehty haluttuun kohtaan reikä 58a. Kun asetetaan säteilevä elementti, jota kuvassa ei ole esitetty, reiän 58a läheisyyteen, on siitä seurauksena, että osa elementin säteilemästä kentästä siirtyy reiän 58a kautta keksinnön mukaiseen aaltojohtoon. Kyseinen säteilevä elementti voi olla mikä tahansa säteilemään kykenevä piirielementti tai mahdollisesti toinen keksinnön mukainen aaltojohto, jonka seinämään on tehty vastaavan muotoinen säteilemään pystyvä reikä. Valitsemalla säteilevä taajuus oikein saadaan aaltojohdossa herätettyä halutun aaltomuodon mukainen etenemään pystyvä sähkömagneettinen aaltomuoto.

Kuvassa 5b on esitetty eräs toinen mahdollinen tapa herättää keksinnön mukaisessa aaltojohdossa etenemään kykenevä aaltomuoto. Kuvan 5b esimerkissä aaltojohdon ytimen 53b erottaa muusta piirirakenteesta, jota kuvassa esittävät rakenteen osat 51b ja 57b, ilmatäytteiset onkalot 52b ja 56b sekä johtavasta materiaalista muodostetut oleellisesti yhdensuuntaiset ensimmäinen taso 54b ja toinen taso 55b. Halutun aaltomuodon herättämiseksi keksinnön mukaisessa aaltojohdossa on johtavaan ensimmäiseen tasoon 54b tehty haluttuun kohtaan reikä 58b, josta on viety aaltojohdon ydinosaan 53b sylinterinmuotoinen sondi 59b. Sondi on edullisesti valmistettu samasta johtavasta materiaalista kuin aaltojohdon tasomaiset ensimmäinen pinta 54b ja toinen pinta 55b. Sondi 59b kytketään haluttuun signaalin tuovaan johtimeen tasomaisen ensimmäisen pinnan 54b yläpuolisissa piirirakenteissa. Kyseinen signaalijohdin voi olla esimerkiksi liuskajohto tai mikroliuskajohto. Mainittua johdinta ja muita yläpuolisia piirirakenteita ei ole esitetty kuvassa 5b.

Kuvassa 5c on esitetty eräs kolmas mahdollinen tapa herättää keksinnön mukaisessa aaltojohdossa etenemään kykenevä aaltomuoto. Kuvan 5c esimerkissä aaltojohdon ytimen 53c erottaa muusta kokonaisuudesta, jota kuvassa esittävät rakenteen osat 51c ja 57c, ilmatäytteiset onkalot 52c ja 56c sekä johtavasta materiaalista muodostetut oleellisesti yhdensuuntaiset ensimmäinen taso 54c ja toinen taso 55c.

Halutun aaltomuodon herättämiseksi muodostetussa aaltojohdossa on johtavasta materiaalista valmistettuun ensimmäiseen tasoon 54c tehty haluttuun kohtaan reikä 58c, josta on viety aaltojohdon ydinosaa 53c kytkentäsilmukka 59c. Kytkentäsilmukka 59c kytketään haluttuun signaalin tuovaan johtimeen tasomaisen ensimmäisen pinnan 54c yläpuolisissa piirirakenteissa. Kyseinen signaalijohdin voi olla esimerkiksi liuskajohto, mikroliuskajohto tai koplaanaarijohto. Kyseistä signaalia tuovaa johdinta ja muita yläpuolisia piirirakenteita ei ole esitetty kuvassa 5c. Kytkentäsilmukka 59c valmistetaan johtavasta materiaalista muun monikerroskeramiikkatekniikalla toteutetun piirirakenteen valmistuksen yhteydessä.

Kuvassa 6a on esimerkinomaisesti esitetty, miten mikroliuskajohtimen ja keksinnön mukaisen aaltojohdon yhteenliittäminen voidaan suorittaa. Kuvassa on esitetty yz-tasossa oleva leikkauskuvanto johtojen yhdistämiskohdasta. Piirirakenne on toteutettu liittämällä yhteen useita kerroksia keraamisia levyjä 61a. Mikroliuskajohdon osuuden 60a muodostavat signaalijohdin 63a ja maajohdin 62a. Siirtojohdon impedanssi muuttuu mikroliuskajohdon ja aaltojohdon 68a yhtymäkohdassa. Suuret impedanssien epäsovitukset aiheuttavat mainitussa rajapinnassa epätoivottua signaalin heijastumista takaisin tulosuuntaansa. Tätä heijastumisongelmaa voidaan pienentää tekemällä liitoskohtaan rakenne, jossa asteittain muutetaan siirtojohdon impedanssitasoa. Kuvan 6a esimerkissä tämä impedanssien sovitus on tehty ns. neljännesaaltomuuntajalla 67a. Se muodostuu kuvan z-akselin suuntaan $\lambda/4$:n pituisista askelmaisista aaltojohdon geometrian muutoksista. Kuvassa 6a se saadaan aikaiseksi johtavilla tasopinnoilla 66a, jotka on y-akselin suunnassa yhdistetty toisiinsa johtavasta materiaalista valmistetuilla läpivienti rei'illä 64a. X-akselin suuntaan kyseiset tasot 66a ulottuvat koko aaltojohdon ydinosan poikki. Rakenteessa käytettävä keraaminen materiaali on sähköisiltä ominaisuuksiltaan kuvan esimerkissä samanlaista piirirakenteen kaikissa osissa.

Kuvassa 6b on esimerkinomaisesti esitetty toinen tapa, miten keksinnön mukaisen aaltojohdon yhteenliittäminen toiseen sähköiseen piiriin voidaan toteuttaa. Kuvassa on esitetty yz-tasossa oleva leikkauskuvanto siirtojohtojen yhdistämiskohdasta. Komponentin piirirakenne on toteutettu liittämällä yhteen useita kerroksia keraamisia levyjä 61b. Herätesignaali tuodaan aaltojohtoon lieriömäisen sondin 63b avulla. Kuvan esimerkissä sondi tulee aaltojohtoon 68b sen yläpinnan muodostavan ensimmäisen tason 62b ja siihen tehdyn aukon 68b kautta. Täten sondi 63b ei ole galvaanisessa yhteydessä johtavaan ensimmäiseen tasopintaan 62b. Itse sondi 63b voi ulottua kuvan y-akselin suunnassa tarvittaessa useiden keraamisten piirirakenteiden läpi. Signaalin syöttökohtaan syntyvää impedanssiepäsovitusta pienenne-

tään kuvan 6a selityksen yhteydessä kuvatunlaisella neljännesaaltomuuntajalla 67b. Kyseinen neljännesaaltomuuntaja 67b koostuu johtavista tasopinnoista 66b, jotka on kuvan y-akselin suunnassa yhdistetty toisiinsa johtavasta materiaalista valmistetuilla läpivientirei'illä 64b. Kuvan x-akselin suuntaan kyseiset tasot 66b ulottuvat koko aaltojohdon ydinosan poikki. Rakenteessa käytettävä keraaminen materiaali on sähköisiltä ominaisuuksiltaan kuvan esimerkissä samanlaista piirirakenteen kaikissa osissa.

Keksinnön mukaisille aaltojohtojen suoritusmuodoille on suoritettu laskennallisia simulointeja. Simuloinnit on suoritettu molemmille keksinnön mukaisille suoritusmuodoille samoilla rakennemitoilla, jolloin aaltojohdon ydinosan mitta a on ollut 5 mm, mitta b 2 mm, keraamisen materiaalin $\varepsilon_r = 5,9$ ja aaltojohtorakenteeseen kuuluvien ilmatäytteisten onkaloiden x-akselin suuntainen mitta L = 2,5 mm. Simuloinnissa on käytetty TE_{10}-mukaista toimintamoodia ja käytettävänä taajuutena on ollut 18 GHz. Simuloinnit ovat antaneet tulokseksi keksinnön mukaiselle ensimmäiselle suoritusmuodolle vaimennukseksi 1,7 dB/cm. Keksinnön toisen suoritusmuodon mukaiselle aaltojohtorakenteelle on saatu samoilla rakennemitoilla a ja b ja samalla taajuudella 18 GHz vaimennuksen arvoksi 0,7 dB/cm.

Edellä on kuvattu eräitä keksinnön mukaisia edullisia suoritusmuotoja. Keksintö ei rajoitu juuri kuvattuihin ratkaisuihin. Keksinnöllistä ajatusta voidaan soveltaa lukuisilla tavoilla patenttivaatimusten asettamissa rajoissa.

Patenttivaatimukset

1. Menetelmä aaltojohdon valmistamiseksi monikerroskeramiikkatekniikalla valmistettaviin piirirakenteisiin, jonka piirirakenteen mitat ja rakennesuunnat ovat määriteltävissä toisiaan vastaan kohtisuorien x-, y- ja z-akselien avulla, ja jossa valmistusmenetelmässä piirikokonaisuus kootaan erillisistä keraamisista kerroksista (41, 61a, 61b), joiden kerrosten permittiivisyys ε_r on ilman vastaavaa arvoa suurempi ja joihin kerroksiin tehdään halutun muotoisia onkaloita (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) ja reikiä (38, 39, 48, 49, 64a, 64b) ja jonka keraamisen kerroksen pinnalle silkkipainetaan haluttuun kohtaan halutun muotoinen johtava materiaalikerros (24, 25, 34, 35, 44, 45, 54a, 54b, 55c, 55a, 55b, 55c, 62a, 62b, 65a, 65b), ja joka piirirakenne saatetaan valmiiksi saattamalla piirikokonaisuus korkeaan lämpötilaan, **tunnettu** siitä, että oleellisesti z-akselin suuntaisen aaltojohdon muodostamiseksi

- piirirakenteeseen muodostetaan ainakin kaksi oleellisesti rakenteen yz-tason kanssa yhdensuuntaista, aaltojohdon pituista impedanssin epäjatkuvuuskohtaa, joilla impedanssin epäjatkuvuuskohdilla rajataan x-akselin suunnassa aaltojohdon ydinosan (23, 33, 43, 53a, 53b, 53c) mitta a, ja
- että xz-tasossa aaltojohdon ydinosa (23, 33, 43, 53a, 53b, 53c) rajataan oleellisesti yhdensuuntaisilla ensimmäisellä (24, 34, 44, 54a, 54b, 54c, 62a, 62b) ja toisella (25, 35, 45, 55a, 55b, 55c, 65a, 65b) tasolla johtavaa materiaalia, jotka valmistetaan aaltojohdon ydinosan muodostavien keraamisten kerrosten ylä- ja alapuolelle y-akselin suuntaan katsottuna ja joilla johtavilla ensimmäisellä ja toisella tasolla rajataan y-akselin suunnassa aaltojohdon ydinosan (23, 33, 43, 53a, 53b, 53c) mitta b.

2. Patenttivaatimuksen 1 mukainen aaltojohdon valmistusmenetelmä, **tunnettu** siitä, että mainitut kaksi oleellisesti rakenteen yz-tason suuntaista aaltojohdon pituista impedanssin epäjatkuvuuskohtaa saadaan aikaan muodostamalla rakenteeseen aaltojohdon ydinosan (23) molemmille puolille oleellisesti z-akselin suuntaiset ilmatäytteiset onkalot (22, 26).

3. Patenttivaatimuksen 1 mukainen aaltojohdon valmistusmenetelmä, **tunnettu** siitä, että kaksi oleellisesti rakenteen yz-tason suuntaista aaltojohdon pituista impedanssin epäjatkuvuuskohtaa saadaan aikaiseksi

- muodostamalla rakenteeseen aaltojohdon ydinosan (33) molemmille puolille oleellisesti z-akselin suuntaiset ilmatäytteiset onkalot (32, 36)
- sekä sijoittamalla aaltojohdon ydinosaan (33) lähelle molempia ilmatäytteisiä onkaloita (32, 36) ainakin yksi rivi johtavalla materiaalilla täyttettäviä, oleellisesti y-

akselin suuntaisia läpivientireikiä (38, 39), joilla yhdistetään galvaanisesti mainitut ensimmäinen (34) ja toinen (35) taso johtavaa materiaalia.

4. Monikerroskeramiikkatekniikalla valmistettaviin piirikokonaisuuksiin integroitu aaltojohto, jonka piirikokonaisuuden mitat ja rakennesuunnat ovat määriteltävissä toisiaan vastaan kohtisuorien x-, y- ja z-akselien avulla ja jossa piirikokonaisuus on kootu erillisistä keraamisista kerroksista (41, 61a, 61b), joiden kerrosten permittiivisyys ε_r on ilman vastaavaa arvoa suurempi ja joihin kerroksiin on valmistettu halutun muotoisia onkaloita (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) ja reikiä (38, 39, 48, 49, 64a, 64b) ja joiden keraamisten kerroksien pinnalle on valmistettu haluttuun kohtaan halutun muotoinen johtava materiaalikerros, **tunnettu** siitä, että aaltojohto käsittää :
- oleellisesti piirikokonaisuuden rakenteen z-akselin suuntaisen aaltojohdon ydinosan (23, 33, 43, 53a, 53b, 53c),
- ainakin kaksi oleellisesti yz-tason suuntaista oleellisesti yhdensuuntaista, aaltojohdon pituista impedanssin epäjatkuvuuskohtaa, joilla on rajattu aaltojohdon ydinosan (23, 33, 43, 53a, 53b, 53c) mitta a x-akselin suunnassa, ja
- ensimmäisen (24, 34, 44, 54a, 54b, 54c, 62a, 62b) oleellisesti xz-tason suuntaisen oleellisesti aaltojohdon pituisen kerroksen johtavaa materiaalia ja toisen (25, 35, 45, 55a, 55b, 55c, 65a, 65b) oleellisesti xz-tason suuntaisen oleellisesti aaltojohdon pituisen kerroksen johtavaa materiaalia, jotka ensimmäinen ja toinen kerros ovat oleellisesti yhdensuuntaiset ja joilla kerroksilla on rajattu aaltojohdon ydinosan (23, 33, 43, 53a, 53b, 53c) mitta b y-akselin suunnassa.

5. Patenttivaatimuksen 4 mukainen aaltojohto, **tunnettu** siitä, että mainitut oleellisesti yz-tason suuntaiset impedanssin epäjatkuvuuskohdat ovat muodostettu ilmatäytteisten onkaloiden (22, 26) ja ydinosan (23) rajapinnan avulla.

6. Patenttivaatimuksen 4 mukainen aaltojohto, **tunnettu** siitä, että mainitut oleellisesti yz-tason suuntaiset impedanssin epäjatkuvuuskohdat on muodostettu
- aaltojohdon ydinosan molemmille puolille oleellisesti z-akselin suuntaisesti sijoittuvista ilmatäytteisistä onkaloista (32, 36) sekä
- aaltojohdon ydinosaan (33) lähelle molempia ilmatäytteisiä onkaloita (32, 36) ainakin yhteen riviin sijoitetuista oleellisesti y-akselin suuntaisista, johtavalla materiaalilla täytetyistä läpivientirei'istä (38, 39), joilla on yhdistetty mainittu ensimmäinen kerros ja mainittu toinen kerros.

7. Patenttivaatimuksen 4 mukainen aaltojohto, **tunnettu** siitä, että aaltojohdon ensimmäiseen pintaan (54a) on tehty reikä (58a) aaltojohdossa etenemään tarkoitetun sähkömagneettisen kentän herättämiseksi.

8. Patenttivaatimuksen 4 mukainen aaltojohto, **tunnettu** siitä, että aaltojohdon ensimmäiseen pintaan (54b) on tehty reikä (58b), jonka kautta aaltojohdon ydinosaan (53b) on johdettu sondi (59b) aaltojohdossa etenemään tarkoitetun sähkömagneettisen kentän herättämiseksi.

9. Patenttivaatimuksen 4 mukainen aaltojohto, **tunnettu** siitä, että aaltojohdon ensimmäiseen pintaan (54c) on tehty reikä (58c), jonka kautta aaltojohdon ydinosaan (53c) on johdettu kytkentäsilmukka (59c) aaltojohdossa etenemään tarkoitetun sähkömagneettisen kentän herättämiseksi.

(57) Tiivistelmä

Keksinnön kohteena on aaltojohdon valmistusmenetelmä sekä menetelmällä valmistettu aaltojohto, joka voidaan integroida osaksi monikerroskeramiikkatekniikalla valmistettua piirirakennetta. Aaltojohdon ydinosan (23, 33, 43, 53a, 53b, 53c) muodostaa keraamisista kerroksista koottu kokonaisuus, jonka rajaavat yz-tasossa kaksi impedanssin epäjatkuvuuskohtaa sekä xz-tasossa kaksi johtavasta materiaalista valmistettua tasomaista pintaa (24, 25, 34, 35, 54a, 54b, 54c, 55a, 55b, 55c). Kyseiset johtavat pinnat voidaan yhdistää toisiinsa johtavasta materiaalista valmistetuilla läpivientirei'illä (38, 39, 48, 49). Keksinnön mukaisella menetelmällä valmistettu aaltojohto on kiinteä osa piirirakennekokonaisuutta.

Kuva 3

PATENT OFFICE
PATENTTI- JA REKISTERIHALLITUS
Patentti- ja innovaatiolinja

SEARCH REPORT 10/030502
TUTKIMUSRAPORTTI
531 Rec'd PCT 08 JAN 2002

PATENTTIHAKEMUS NRO Application No.	**LUOKITUS** Classification
991585	H01P 3/16, H01P 11/00

TUTKITTU AINEISTO MATERIAL SEARCHED

Patenttijulkaisukokoelmasta (FI, SE, NO, DK, DE, CH, EP, WO, US) tutkitut luokat:
Patent publication collection (...), classes searched
H01P 1/20, 1/203, 3/00, 3/02, 3/08, 3/12, 3/16, 3/18, 7/10, 11/00

sekä lisäksi tutkitut FI-luokat:
and further searched FI classes
H01P 1/201, 1/207, 5/00

Tiedonhaut ja muu aineisto Data retrievals and other material
Seuraavat tietokannat: WPI, PAJ, EPODOC

VIITEJULKAISUT REFERENCES CITED

Kategoria*) Category*)	**Julkaisun tunnistetiedot** Identification data of publication	Concerns claims **Koskee vaatimuksia**
X	EP 0883328A1 (H05K 1/02)	1, 4, 7-9
X	JP 10107518 (H01P 5/107), vain tiivist.	- " -
X	EP 0767507A1 (H01P 3/16)	1,2,4,5,7-9
X	EP 0858123A3 (H01P 3/16)	- " -

*) X Patentoitavuuden kannalta merkittävä julkaisu yksinään tarkasteltuna
Y Patentoitavuuden kannalta merkittävä julkaisu, kun otetaan huomioon tämä ja yksi tai useampi samaan kategoriaan kuuluva julkaisu
A Yleistä tekniikan tasoa edustava julkaisu, ei kuitenkaan patentoitavuuden este

Päiväys Date	**Tutkija** Examiner
30. 6. 2000	Timo Huttunen

*) X Document of particular relevance when considered alone
Y Document of particular relevance when combined with one or more documents of the same category
A Document representing the state of the art

10/030502

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

REC'D 27 NOV 2001

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference OP100021/JUM	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/FI00/00635	International filing date *(day/month/year)* 10.07.2000	Priority date *(day/month/year)* 09.07.1999
International Patent Classification (IPC) or national classification and IPC7 H 01 P 3/16, H 05 K 1/02, H 05 K 3/46		
Applicant Nokia Corporation et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10.01.2001	12.11.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88	Authorized officer Bo Gustavsson/AE Telephone No. 08-782 25 00

Telex 17978 PATOREG-S

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI00/00635

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages 1-10 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☒ the claims:
pages _____ , as originally filed
pages _____ , as amended (together with any statement) under article 19
pages _____ , filed with the demand
pages 11-13 , filed with the letter of 28.08.2001

☒ the drawings:
pages 1/4-4/4 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☐ the sequence listing part of the description:
pages _____ , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language English which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☒ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI00/00635

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-7	YES
	Claims		NO
Inventive step (IS)	Claims	1-7	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-7	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The claimed invention as described in the amended claims 1-7 is considered to have novelty and to involve an inventive step in view of the documents cited in the International Search Report.

Documents cited in the International Search Report:

D1 EP 0883328 A1
D2 EP 0858123 A2
D3 EP 0767507 A1

From D1, a circuit board comprising a high-frequency transmission line is known. The board is manufactured by laminating a plurality of dielectric (e.g. ceramic) layers, the permittivity of which is higher than that of air. In the dielectric layers cavities and holes are formed having desired shapes and conductive planes are formed by printing. A waveguide structure is formed by limiting a volume in one direction using two (or more) rows of metallized via holes and in another direction using the metallic planes above and below the ceramic layers. An impedance discontinuity is formed on each side of the waveguide structure parallel to the rows of via holes by forming additional intermediate metallic planes in parallel to the first planes.
The main difference between the claimed invention as described in the amended claims is that, according to the invention, air-filled cavities are used as impedance discontinuity formers.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Box V

D2 and D3 show prior-art dielectric waveguides made from multilayered dielectric structures. None of the devices according to the cited documents anticipates the invention as described in the amended claims.

The claimed invention as decsribed in the amended claims 1-7 therefore have novelty. It is not considered to be obvious for a person skilled in the art to arrive at a waveguide structure as described in the claims in view of the cited documents. The invention therefore involves an inventive step. The invention is also considered to have industrial applicability.

Claims

1. A method for manufacturing a waveguide in circuit structures manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit structures can be determined by means of x, y and z axes perpendicular to each other, and the circuit unit is assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape are made and on the surface of which ceramic layer a conductive layer of material (24, 25, 34, 35, 44, 45, 54a, 54b, 54c, 55a, 55b, 55c, 62a, 62b, 65a, 65b) is silk screen printed on the desired location, and the circuit structure is completed by exposing the circuit structure to a high temperature, and in which method for creating a waveguide essentially in the direction of the z-axis

- at least two impedance discontinuities essentially parallel with the yz plane of the structure and of the length of the waveguide are formed in the circuit structure to limit the length a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis,
- and in the xz plane the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide is limited by essentially parallel first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) and second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) planes of conductive material, which are manufactured above and below the ceramic layers that form the core part of the waveguide in the direction of the y-axis, and which conductive first and second planes are used to limit the measure b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis,

characterized in that

in the method for creating a waveguide essentially in the direction of the z-axis said two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished by forming air-filled cavities (22, 26) essentially in the direction of the z-axis on both sides of the core part (23) of the waveguide in the structure

2. A waveguide manufacturing method according to Claim 1, **characterized** in that two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished

- by forming air-filled cavities (32, 36) essentially in the direction of the z-axis on both sides of the core part (33) of the waveguide in the structure
- and by placing in the core part (33) of the waveguide close to both air-filled cavities (32, 36) at least one row of vias (38, 39) filled with conductive material and essentially in the direction of the y-axis, by which said first (34) and second (35) planes of conductive material are galvanically connected.

3. A waveguide integrated into circuit units manufactured with the multilayer ceramic technique, wherein the dimensions and structural directions of the circuit units can be determined by means of x, y and z axis perpendicular to each other, and the circuit unit has been assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape have been made, and on the surface of which ceramic layers a layer of conductive material has been made on the desired location, which waveguide comprises:
- a core part of the waveguide (23, 33, 43, 53a, 53b, 53c) essentially in the direction of the z-axis of the structure of the circuit unit,
- at least two impedance discontinuities essentially in the direction of the yz plane, essentially parallel and of the length of the waveguide, which limit the dimension a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis, and
- a first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, and
- a second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide,
which first and second layers are essentially parallel and which limit the dimension b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis,
characterized in that
said impedance discontinuities essentially in the direction of the yz plane have been formed by means of the air-filled cavities (22. 26) and the interface of the core part (23).

4. A waveguide according to Claim 3, **characterized** in that said impedance discontinuities essentially in the direction of the yz plane have been formed
- of air-filled cavities (32, 36) placed essentially in the direction of the z-axis on both sides of the core part of the waveguide, and
- of vias (38, 39) essentially in the direction of the y-axis, filled with conductive material and placed in at least one row in the core part (33) of the waveguide close to both air-filled cavities, by which vias said first and second layers have been connected.

5. A waveguide according to Claim 3, **characterized** in that a hole (58a) has been made in the first surface (54a) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

6. A waveguide according to Claim 4, **characterized** in that a hole (58b) has been made in the first surface (54b) of the waveguide, through which hole a probe (59b) has been led to the core part (53b) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

7. A waveguide according to Claim 3, **characterized** in that a hole (58c) has been made in the first surface (54c) of the waveguide, through which hole a coupling loop (59c) has been led to the core part (53c) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

PCT REQUEST

50065

Original (for SUBMISSION) - printed on 10.07.2000 09:54:33 AM

0 0-1	**For receiving Office us nly** International Application No.	
0-2	International Filing Date	
0-3	Name of receiving Office and "PCT International Application"	
0-4 0-4-1	**Form - PCT/RO/101 PCT Request** Prepared using	PCT-EASY Version 2.90 (updated 10.05.2000)
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	National Board of Patents and Registration (Finland) (RO/FI)
0-7	**Applicant's or agent's file reference**	50065
I	**Title of invention**	METHOD FOR CREATING WAVEGUIDES IN MULTILAYER CERAMIC STRUCTURES AND A WAVEGUIDE
II II-1 II-2 II-4 II-5 II-6 II-7 II-8 II-9	**Applicant** This person is: Applicant for Name Address: State of nationality State of residence Telephone No. Facsimile No.	 applicant only all designated States except US NOKIA NETWORKS OY P.O. Box 300 FIN-00045 Nokia Group Finland FI FI +358-9-51121 +358-9-51168080
III-1 III-1-1 III-1-2 III-1-4 III-1-5 III-1-6 III-1-7	**Applicant and/or inventor** This person is: Applicant for Name (LAST, First) Address: State of nationality State of residence	 applicant and inventor US only SALMELA, Olli Haahkakuja 1 D 41 FIN-00200 Helsinki Finland FI FI

PCT REQUEST 50065

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III-2	**Applicant and/or inventor**	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	KEMPPINEN, Esa
III-2-5	Address:	Vermonrinne 17 A FIN-00370 Helsinki Finland
III-2-6	State of nationality	FI
III-2-7	State of residence	FI
III-3	**Applicant and/or inventor**	
III-3-1	This person is:	applicant and inventor
III-3-2	Applicant for	US only
III-3-4	Name (LAST, First)	SOMERMA, Hans
III-3-5	Address:	Mäkeläntie 1 FIN-02880 Veikkola Finland
III-3-6	State of nationality	FI
III-3-7	State of residence	FI
III-4	**Applicant and/or inventor**	
III-4-1	This person is:	applicant and inventor
III-4-2	Applicant for	US only
III-4-4	Name (LAST, First)	IKÄLÄINEN, Pertti
III-4-5	Address:	Pähkinälehto 27 FIN-03150 Huhmari Finland
III-4-6	State of nationality	FI
III-4-7	State of residence	FI
III-5	**Applicant and/or inventor**	
III-5-1	This person is:	applicant and inventor
III-5-2	Applicant for	US only
III-5-4	Name (LAST, First)	KOIVISTO, Markku
III-5-5	Address:	Niittykatu 3 C 41 FIN-02200 Espoo Finland
III-5-6	State of nationality	FI
III-5-7	State of residence	FI
IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name	BERGGREN OY AB
IV-1-2	Address:	P.O. Box 16 FIN-00101 Helsinki Finland
IV-1-3	Telephone No.	+358-9-693701
IV-1-4	Facsimile No.	+358-9-6933944
IV-1-5	e-mail	email.box@berggren.fi

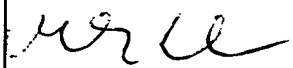
PCT REQUEST 50065

Original (for **SUBMISSION**) - printed on 10.07.2000 09:54:33 AM

V	Designation f Stat s	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	**Exclusion(s) from precautionary designations**	NONE
VI-1	**Priority claim of earlier national application**	
VI-1-1	Filing date	09 July 1999 (09.07.1999)
VI-1-2	Number	991585
VI-1-3	Country	FI
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1

PCT REQUEST 50065

Original (for **SUBMISSION**) - printed on 10.07.2000 09:54:33 AM

VII-1	Int rnati nal Searching Authority Ch sen	Swedish Patent Office (ISA/SE)	
VIII	Ch ck list	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	10	-
VIII-3	Claims	3	-
VIII-4	Abstract	1	50065.txt
VIII-5	Drawings	4	-
VIII-7	TOTAL	22	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-9	Separate signed power of attorney	✓	-
VIII-10	Copy of general power of attorney	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-17	Other (specified):	Copy of Official Action in FI 991585	-
VIII-18	**Figure of the drawings which should accompany the abstract**	3	
VIII-19	**Language of filing of the international application**	Finnish	
IX-1	**Signature of applicant or agent**		
IX-1-1	Name	BERGGREN OY AB	
IX-1-2	Name of signatory	Markus Levlin	
IX-1-3	Capacity	Patent Attorney	

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/SE
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	

10/030502

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ SE

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION

Applicant's or agent's file reference: OP100021/JUM

International application No.	International filing date *(day/month/year)*	(Earliest) Priority date *(day/month/year)*
PCT/FI00/00635	10 July 2000 (10.07.2000)	9 July 1999 (09.07.1999)

Title of invention

METHOD FOR CREATING WAVEGUIDES IN MULTILAYER CERAMIC STRUCTURES AND A WAVEGUIDE

Box No. II APPLICANT(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

NOKIA NETWORKS OY et al
P.O. Box 300
FIN-00045 Nokia Group
Finland

Telephone No.: +358-9-51121
Facsimile No.: +358-9-51168080
Teleprinter No.:

State *(that is, country)* of nationality: Finland
State *(that is, country)* of residence: Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

SALMELA, Olli
Haahkakuja 1 D 41
FIN-00200 Helsinki
Finland

State *(that is, country)* of nationality: Finland
State *(that is, country)* of residence: Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

KEMPPINEN, Esa
Vermonrinne 17 A
FIN-00370 Helsinki
Finland

State *(that is, country)* of nationality: Finland
State *(that is, country)* of residence: Finland

[X] Further applicants are indicated on a continuation sheet.

Sheet No. 2.

International application No.
PCT/FI00/00635

Continuation of Box No. II APPLICANT(S)

If none of the following sub-boxes is used, this sheet should not be included in the demand.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

SOMERMA, Hans
Mäkeläntie 1
FIN-02880 Veikkola
Finland

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
Finland	Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

IKÄLÄINEN, Pertti
Pähkinälehto 27
FIN-03150 Huhmari
Finland

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
Finland	Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

KOIVISTO, Markku
Niittykatu 3 C 41
FIN-02200 Espoo
Finland

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
Finland	Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

☐ Further applicants are indicated on another continuation sheet.

International application No.
PCT/FI00/00635

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is [X] agent [ ] common representative

and [X] has been appointed earlier and represents the applicant(s) also for international preliminary examination.

[ ] is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.

[ ] is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

OULUN PATENTTITOIMISTO BERGGREN OY AB
Teknologiantie 14 D
FIN-90570 Oulu
Finland

Telephone No.: +358-8-5515670

Facsimile No.: +358-8-5566701

Teleprinter No.:

[ ] **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special addr ess to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments:*

1. The applicant wishes the international preliminary examination **to start on the basis of:**

[X] the international application as originally filed

the description [X] as originally filed
[ ] as amended under Article 34

the claims [X] as originally filed
[ ] as amended under Article 19 (together with any accompanying statement)
[ ] as amended under Article 34

the drawings [X] as originally filed
[ ] as amended under Article 34

2. [ ] The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. [ ] The applicant wishes the start of the international preliminary examination **to be postponed** until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

[ ] which is the language in which the international application was filed.
[X] which is the language of a translation furnished for the purposes of international search.
[ ] which is the language of publication of the international application.
[ ] which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby elects **all eligible States** *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes **not to elect:**

International application No.
PCT/FI00/00635

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:

			For International Preliminary Examining Authority use only: received	not received
1. translation of international application	:	sheets	☐	☐
2. amendments under Article 34	:	sheets	☐	☐
3. copy (or, where required, translation) of amendments under Article 19	:	sheets	☐	☐
4. copy (or, where required, translation) of statement under Article 19	:	sheets	☐	☐
5. letter	:	sheets	☐	☐
6. other *(specify)*	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. ☐ fee calculation sheet
2. ☐ separate signed power of attorney
3. [X] copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ nucleotide and or amino acid sequence listing in computer readable form
6. ☐ other *(specify)*:

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

Oulu, 10 January 2001

Jukka Määttä
Patent Attorney
OULUN PATENTTITOIMISTO BERGGREN OY AB

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.
4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA on:

PCT

CHAPTER II

FEE CALCULATION SHEET

Annex to the Demand for international preliminary examination

International application No. PCT/FI00/00635	For International Preliminary Examining Authority use only
Applicant's or agent's file reference OP100021/JUM	Date stamp of the IPEA
Applicant: NOKIA NETWORKS OY et al	

Calculation of prescribed fees

1. Preliminary examination fee	SEK 4200	P	
2. Handling fee *(Applicants from certain States are entitled to a reduction of 75% of the handling fee. Where the applicant is (or all applicants are) so entitled, the amount to be entered at H is 25% of the handling fee.)*	SEK 1270	H	
3. Total of prescribed fees Add the amounts entered at P and H and enter total in the TOTAL box	SEK 5470 TOTAL		

Mode of Payment

☐	authorization to charge deposit account with the IPEA (see below)	☐	cash
☐	cheque	☐	revenue stamps
☐	postal money order	☐	coupons
☒	bank draft via SWIFT through account 5439-10-013-49	☐	other *(specify)*:

Deposit Account Authorization *(this mode of payment may not be available at all IPEAs)*

The IPEA/_____ ☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☐ *(this check-box may be marked only if the conditions for deposit accounts of the IPEA so permit)* is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

Deposit Account Number _____ Date *(day/month/year)* _____ Signature _____

See Notes to the fee calculation sheet

Berggren

Patentit, hyödyllisyysmallit, tavaramerkit ja mallit
Patents, Utility Models, Trademarks and Designs

YLEIS-
VALTAKIRJA
Täten

OULUN PATENTTITOIMISTO
Berggren Oy Ab
00101 HELSINKI • PL 16 / Teknologiantie 14 D
90570 OULU

tai määräämänsä valtuutetaan
hoitamaan mitä tahansa teollisoikeuksiin
liittyvää asiaa/hakemusta

GENERAL
POWER OF ATTORNEY
for

OULUN PATENTTITOIMISTO
Berggren Oy Ab
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FIN-90570 OULU

or any one they may appoint as their substitute
to attend to any case/application
relating to industrial property rights

sekä kaikessa, mikä asiaa/hakemusta, tästä jakamalla erotettuja ja lohkaistuja hakemuksia ja hakemusten perusteella myönnettyjä suojaoikeuksia koskee, kantamaan ja vastaamaan, hyväksyen kaiken, minkä asiamies laillisesti tekee tai tekemättä jättää.

and to act on my/our behalf in all proceedings concerning the case/application, applications divided and separated from these and rights granted on said applications, and thereby I/we approve of any legal actions taken or not taken by the Attorney.

Kääntöpuolella olevat ehdot, YT 96, koskevat kaikkia toimeksiantoja, joista asiamies saattaa joutua huolehtimaan.

The YT 96 conditions overleaf apply to any commissions the attorney may undertake.

NOKIA NETWORKS OY

Paikka, päiväys ja hakijan allekirjoitus
ESKO FRIMAN
VP, Intellectual Property Rights
Helsinki, 29.8.2000

Mika U Anttila
Director of IPR, Finland

Place, date and Applicant's signature

Ei vahvistusta

No legalization

MUISTILÄHETYKSEN RAPORTTI

AIKA : 10-01-2001 14:25
PUH NUMERO1: +358 8 5566701 -
NIMI : OULUN PATENTTITOIMISTO

TIED.NUMERO	:	933
PVM	:	10-01 14:22
KENELLE	:	9904686677288
SIVUJA	:	007
LÄHTöAIKA	:	10-01 14:22
LOPPU AIKA	:	10-01 14:25
LÄHETETYT	:	007
TILA	:	OK

TIED.NUMERO : 933 *** ONNISTUNUT LÄHETYSTIEDOTE ***

OULUN PATENTTITOIMISTO
PATENT & TRADEMARK ATTORNEYS

- patentit *patents*
- hyödyllisyysmallit *utility models*
- tavaramerkit *trademarks*
- mallisuojat *designs*
- lakiasiat *legal matters*

10 January 2001
FAX (7 pp.) — Original by mail

Patent- och registreringsverket
Valhallavägen 136
P.O. Box 5055
S-10242 STOCKHOLM
Sweden

Our Ref: OP100021/JUM/PJ

INTERNATIONAL APPLICATION NO. PCT/FI00/00635
NOKIA NETWORKS OY et al.
TERM: 9 February 2001

We enclose the Demand for this PCT-application. The fees related to the Demand, i.e. fee for the preliminary examination SEK 4200 and the handling fee SEK 1270, have been transferred onto your bank account.

Please find also enclosed a copy of general power of attorney signed by the applicant.

OULUN PATENTTITOIMISTO
BERGGREN OY AB
for Jukka Määttä

Pirjo Junnila
Patent Assistant

Encl. Demand
Copy of general power of attorney

Oulun Patenttitoimisto
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LY 0107002-7
VAT FI01070027
Kotipaikka Helsinki

PATENT COOPERATION TREAT

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 50065	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/FI 00/00635	International filing date *(day/month/year)* 10 July 2000	(Earliest) Priority Date *(day/month/year)* 9 July 1999
Applicant NOKIA NETWORKS OY ET AL.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[x] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the title,
   - [x] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the abstract,
   - [x] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is:
   Figure No. 3
   - [x] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00635

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01P 3/16, H05K 1/02, H05K 3/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, H01P, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0883328 A1 (KYOCERA CORPORATION), 9 December 1998 (09.12.98), column 2, line 26 - column 3, line 54; column 5, line 20 - column 8, line 50; column 10, line 7 - column 12, line 56, figures 1,5	1,4,7-9
A	--	2,5
A	EP 0858123 A2 (MURATA MANUFACTURING CO., LTD.), 12 August 1998 (12.08.98), column 1, line 55 - column 3, line 22; column 4, line 6 - line 50; column 7, line 11 - line 39	1,2,4,5
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2000	24 -10- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bo Gustavsson/AE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00635

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0767507 A1 (MURATA MANUFACTURING CO., LTD.), 9 April 1997 (09.04.97), column 3, line 16 - column 6, line 22; column 8, line 19 - column 10, line 11 -- --------	1,2,4,5,7-9

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/08/00

International application No.
PCT/FI 00/00635

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0883328 A1	09/12/98	JP 10303608 A	13/11/98
		US 5982256 A	09/11/99
EP 0858123 A2	12/08/98	CN 1195902 A	14/10/98
		JP 10224120 A	21/08/98
EP 0767507 A1	09/04/97	CN 1152804 A	25/06/97
		JP 2998614 B	11/01/00
		JP 9102706 A	15/04/97
		KR 192562 B	15/06/99
		US 5982255 A	09/11/99

PATENT COOPERATION TREATY

10/030502

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

Oulun Patenttitoimisto
Berggren OY AB
Teknologiantie 14 D
FIN-90570 Oulu

03. 08. 2001

PCT

WRITTEN OPINION

(PCT Rule 66)

rap. 15.8.01
ohj. 3.9.01

Date of mailing *(day/month/year)*	01-08-2001 14.9.01 PJ
Applicant's or agent's file reference: OP100021/JUM	**REPLY DUE** within 45 days from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/FI00/00635	10.07.2000	09.07.1999

International Patent Classification (IPC) or both national classification and IPC: H01P 3/16, H05K 1/02, H05K 3/46

Applicant: NOKIA NETWORKS OY ET AL.

1. This written opinion is the first (first, etc.) drawn by this International Preliminary Examining Authority.
2. This opinion contains indications relating to the following items:
   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application
3. The applicant is hereby **invited to reply** to this opinion.
   - **When?** See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).
   - **How?** By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.
   - **Also** For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4*bis*. For an informal communication with the examiner, see Rule 66.6.

   If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.
4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 10.01.2001

Name and mailing address of the IPEA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88 Telex 17978 PATOREG-S	Bo Gustavsson/AE Telephone No. 08-782 25 00

Form PCT/IPEA/408 (cover sheet) (January 1998)

WRITTEN OPINION

International application No.
PCT/FI00/00635

I. Basis of the opinion

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the drawings:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the written opinion was drawn on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☐ the claims, Nos. _____

☐ the drawings, sheet/fig _____

5. ☐ This opinion has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".*

WRITTEN OPINION

International application No.
PCT/FI00/00635

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-9	YES
	Claims		NO
Inventive step (IS)	Claims	2,3,5,6	YES
	Claims	1,4,7-9	NO
Industrial applicability (IA)	Claims	1-9	YES
	Claims		NO

2. Citations and explanations

The claimed invention as described in claims 1, 4 and 7-9 in not considered to involve an inventive step in view of the cited document:

D1 EP 0883328 A1

From D1, a circuit board comprising a high-frequency transmission line is known. The board is manufactured by laminating a plurality of dielectric (e.g. ceramic) layers, the permittivity of which is higher than that of air. In the dielectric layers cavities and holes are formed having desired shapes and conductive planes are formed by printing. A waveguide structure is formed by limiting a volume in one direction using two (or more) rows of metallized via holes and in another direction using the metallic planes above and below the ceramic layers. An impedance discontinuity is formed on each side of the waveguide structure parallel to the rows of via holes by forming additional intermediate metallic planes in parallel to the first planes.
The only difference between the claimed invention as described in claims 1 and 4 is that, according to the invention, the conductive layer on the surface of the ceramic is *silk screen* printed. This, however, is considered to be an obvious alternative for a person skilled in the art. Therefore, the invention as claimed in claims 1 and 4 lacks inventive step.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: BOX V.

As also shown in D1, a coupling between a planar transmission line and the waveguide may be accomplished by making a via hole in the ceramic layers. The via may operate as a antenna or probe for coupling the electromagnetic signals to or from the waveguide (see column 10, line 6-column 12, line 56).
Therefore, the invention as described in claims 7-9 lacks inventive step.

The claimed invention as decsribed in claims 2, 3, 5 and 6 have been found to have novelty and to involve an inventive step.
The invention is also considered to have industrial applicability.

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28 August 2001

FACSIMILE & MAIL (5 pages)

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Valhallavägen 136
Box 5055
S-102 42 STOCKHOLM
Sweden

Authorised officer: Bo Gustafsson

Our ref: OP100021/JUM/JAH

INTERNATIONAL PATENT APPLICATION NO. PCT/FI00/00635
APPLICANT: NOKIA NETWORKS OY et al.

Reply to the Written Opinion mailed on 1 August 2001
Due date: 14 September 2001

Dear Sirs,

In reply to the Written Opinion, mailed on 1 August 2001, issued on the above-identified International Patent Application No. PCT/FI00/00635, we herewith submit a new amended set of claims 1 to 7 and our support to the amended claims. The characterizing part of the amended independent claims (1 and 3) has been modified from the characterizing part of claim 2 in the originally filed set of claims.

The invention in the present application discloses a new method on how to manufacture a waveguide to an essential part of a multilayer ceramic circuit. The waveguide according to the present invention can be dimensioned by normal design equations used in waveguide technology. Two conductive layers (for example metallic planes) form two of the waveguide walls, which are essentially parallel in the xz plane. The other two walls of the waveguide are formed of impedance discontinuities in the ceramic structure. These impedance discontinuities are formed of two air-filled cavities, which are essentially parallel in the yz plane.

The originally filed claims of the present application are considered partly not inventive against EP 0883328 A1 (document D1). In the cited reference D1 a method is disclosed where a waveguide is formed by limiting volume in one direction with two (or more) rows of metallized via holes, and in another direction with metallic planes above and below a ceramic material layer. The first-mentioned rows of metallized vias shape an impedance discontinuity which limits the waveguide dimension in one direction.

However, the cited reference D1 does not disclose air-filled cavities as an impedance discontinuity former. As disclosed in the present application, the air-filled cavities form two impedance

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discontinuities which can in themselves form two walls of the waveguide. In some cases the degree of the impedance discontinuity can be enhanced by rows of metallized vias according to the reference D1.

We respectfully point out that the present application with the amended claims discloses a method with which a waveguide can be economically manufactured to a part of a ceramic circuit structure. Based on the above-mentioned facts the applicant considers the present invention with the amended claims to be novel and patentable over the cited prior art D1 (EP 0883328 A1).

Yours faithfully,
OULUN PATENTTITOIMISTO
BERGGREN OY AB

Jukka Määttä
Patent Attorney

ENCLS Amended set of claims, pages 11–13

Claims

1. A method for manufacturing a waveguide in circuit structures manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit structures can be determined by means of x, y and z axes perpendicular to each other, and the circuit unit is assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape are made and on the surface of which ceramic layer a conductive layer of material (24, 25, 34, 35, 44, 45, 54a, 54b, 54c, 55a, 55b, 55c, 62a, 62b, 65a, 65b) is silk screen printed on the desired location, and the circuit structure is completed by exposing the circuit structure to a high temperature, and in which method for creating a waveguide essentially in the direction of the z-axis

- at least two impedance discontinuities essentially parallel with the yz plane of the structure and of the length of the waveguide are formed in the circuit structure to limit the length a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis,
- and in the xz plane the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide is limited by essentially parallel first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) and second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) planes of conductive material, which are manufactured above and below the ceramic layers that form the core part of the waveguide in the direction of the y-axis, and which conductive first and second planes are used to limit the measure b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis,

characterized in that

in the method for creating a waveguide essentially in the direction of the z-axis said two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished by forming air-filled cavities (22, 26) essentially in the direction of the z-axis on both sides of the core part (23) of the waveguide in the structure

2. A waveguide manufacturing method according to Claim 1, **characterized** in that two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished

- by forming air-filled cavities (32, 36) essentially in the direction of the z-axis on both sides of the core part (33) of the waveguide in the structure
- and by placing in the core part (33) of the waveguide close to both air-filled cavities (32, 36) at least one row of vias (38, 39) filled with conductive material and essentially in the direction of the y-axis, by which said first (34) and second (35) planes of conductive material are galvanically connected.

3. A waveguide integrated into circuit units manufactured with the multilayer ceramic technique, wherein the dimensions and structural directions of the circuit units can be determined by means of x, y and z axis perpendicular to each other, and the circuit unit has been assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape have been made, and on the surface of which ceramic layers a layer of conductive material has been made on the desired location, which waveguide comprises:
- a core part of the waveguide (23, 33, 43, 53a, 53b, 53c) essentially in the direction of the z-axis of the structure of the circuit unit,
- at least two impedance discontinuities essentially in the direction of the yz plane, essentially parallel and of the length of the waveguide, which limit the dimension a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis, and
- a first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, and
- a second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide,
which first and second layers are essentially parallel and which limit the dimension b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis,
characterized in that
said impedance discontinuities essentially in the direction of the yz plane have been formed by means of the air-filled cavities (22, 26) and the interface of the core part (23).

4. A waveguide according to Claim 3, **characterized** in that said impedance discontinuities essentially in the direction of the yz plane have been formed
- of air-filled cavities (32, 36) placed essentially in the direction of the z-axis on both sides of the core part of the waveguide, and
- of vias (38, 39) essentially in the direction of the y-axis, filled with conductive material and placed in at least one row in the core part (33) of the waveguide close to both air-filled cavities, by which vias said first and second layers have been connected.

5. A waveguide according to Claim 3, **characterized** in that a hole (58a) has been made in the first surface (54a) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

6. A waveguide according to Claim 4, **characterized** in that a hole (58b) has been made in the first surface (54b) of the waveguide, through which hole a probe (59b) has been led to the core part (53b) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

7. A waveguide according to Claim 3, **characterized** in that a hole (58c) has been made in the first surface (54c) of the waveguide, through which hole a coupling loop (59c) has been led to the core part (53c) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 January 2001 (18.01.2001)

PCT

(10) International Publication Number
WO 01/04986 A1

(51) International Patent Classification[7]: H01P 3/16, H05K 1/02, 3/46

(21) International Application Number: PCT/FI00/00635

(22) International Filing Date: 10 July 2000 (10.07.2000)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
991585 9 July 1999 (09.07.1999) FI

(71) Applicant *(for all designated States except US)*: **NOKIA NETWORKS OY** [FI/FI]; P.O. Box 300, FIN-00045 Nokia Group (FI).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SALMELA, Olli** [FI/FI]; Haahkakuja 1 D 41, FIN-00200 Helsinki (FI). **KEMPPINEN, Esa** [FI/FI]; Vermonrinne 17 A, FIN-00370 Helsinki (FI). **SOMERMA, Hans** [FI/FI]; Mäkeläntie 1, FIN-02880 Veikkola (FI). **IKÄLÄINEN, Pertti** [FI/FI]; Pähkinälehto 27, FIN-03150 Huhmari (FI). **KOIVISTO, Markku** [FI/FI]; Niittykatu 3 C 41, FIN-02200 Espoo (FI).

(74) Agent: **BERGGREN OY AB**; P.O. Box 16, FIN-00101 Helsinki (FI).

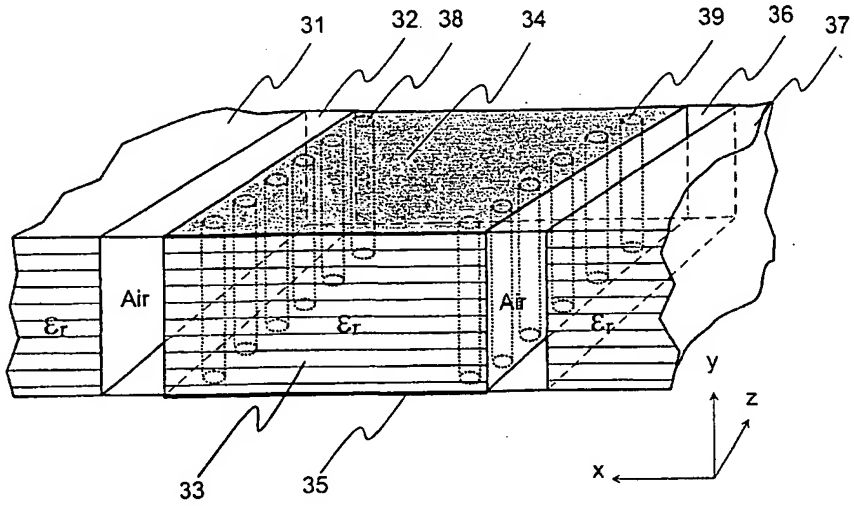
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

[Continued on next page]

(54) Title: METHOD FOR CREATING WAVEGUIDES IN MULTILAYER CERAMIC STRUCTURES AND A WAVEGUIDE



(57) Abstract: The invention relates to a waveguide manufacturing method and a waveguide manufactured with the method, which can be integrated into a circuit structure manufactured with the multilayer ceramic technique. The core part (23, 33, 43, 53a, 53b, 53c) of the waveguide is formed by a unit assembled of ceramic layers, which is limited in the yz plane by two impedance discontinuities and in the xz plane by two planar surfaces (24, 25, 34, 35, 54a, 54b, 54c, 55a, 55b, 55c) made of conductive material. The conductive surfaces can be connected to each other by vias made of conductive material (38, 39, 48, 49). The waveguide manufactured with the method according to the invention is a fixed part of the circuit structure as a whole.

WO 01/04986 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method for creating waveguides in multilayer ceramic structures and a waveguide

The invention relates to a method for creating waveguides in circuit board units manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit board units can be defined by means of x, y and z axes perpendicular to each other, and the circuit board unit is assembled of separate ceramic layers, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities and holes of the desired shape can be made, and on the surface of which ceramic layer a conductive material can be printed at the desired location by silk screen printing, and the circuit board unit is completed by exposing the unit to a high temperature.

The invention also relates to a waveguide integrated into circuit board units manufactured with multilayer ceramics, wherein the dimensions and structural directions of the circuit board units can be defined by means of x, y and z axes perpendicular to each other, and the circuit board unit has been assembled of separate ceramic layers, the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities and holes of the desired shape have been made in the ceramic layers, and on the surface of which ceramic layers a layer of conductive material can be added at the desired location by silk screen printing.

Different conductor structures are used in the structures of electronic devices. The higher the frequencies used in the devices, the greater the requirements set for the conductor structures used, so that the attenuation caused by the conductor structures does not become too high or that the conductor structure used does not disturb other parts of the apparatus by radiation. The designer of the device can select from many possible conductor structures. Depending on the application, an air-filled waveguide made of metal, for example, can be used. The basic structure, dimensions, waveforms that can propagate in the waveguide and the frequency properties of the waveguide are well known (see e.g. chapter 8 Fields and Waves in Communication Electronics, Simon Ramo et al., John Wiley & Sons, inc., USA). Fig. 1 shows, as an example of the dimensioning of a waveguide, a rectangular waveguide made of conductive material, the width of which is a in the direction of the x-axis of the coordinates shown in the figure, the height of which is b in the direction of the y-axis, and which is filled by air, whereby its permittivity ε_r is of magnitude 1. In the

air-filled waveguide shown in Fig. 1, the first (lowest) waveform that can propagate in the direction of the z-axis is the so-called TE_{10} (Transverse-electric) waveform. The electric field E of this waveform does not have a component in the direction of the z-axis at all. Instead, the magnetic field H has a component in the direction of propagation, the direction of the z-axis. The so-called cut-off frequency f_c of the waveform TE_{10}, which means the lowest frequency that can propagate in the waveguide, is obtained from the equation:

$$f_{cTE_{10}} = c/2a$$

where the letter a means the width a of the waveguide in the direction of the x-axis, and c is the speed of light in a vacuum. Generally, the usable frequency range of the waveguide is 1.2 to 1.9 times the cut-off frequency of the waveform in question. The usable lower limiting frequency is determined by the growth of the attenuation when the cut-off frequency f_c is approached from above. The upper frequency limit again is determined by the fact that with frequencies that are more than twice the cut-off frequency f_c of the desired waveform, other waveforms that are capable of propagating are also created in the waveguide, and this should be avoided.

There are also known waveguide structures, in which the waveguide is formed by a core part made of dielectric material, which is coated with a thin layer of conductive material. However, these waveguides are always made as separate components. The above described waveguide structures provide a small attenuation per unit of length, and they do not emit much interference radiation to the environment. However, the problem with these waveguides is the large physical size compared to the rest of the circuit unit to be manufactured, and the fact that it is difficult to integrate their manufacture into the manufacture of the circuit unit as a whole. These waveguides must be joined to the circuit unit mechanically either by soldering or by some other mechanical joint in a separate step, which increases costs and the risk of failure.

Conductor structures that are better integrated into the structure are also utilized in electronic equipment. These include strip lines, microstrips and coplanar conductors. Their manufacture can be integrated into the manufacture of the circuit unit as a whole, when circuit units are manufactured as ceramic structures. This manufacturing technique is called multilayer ceramics, and it is based either on the HTCC (High Temperature Cofired Ceramics) or LTCC (Low Temperature Cofired Ceramics) technique. The circuit structures implemented with either of these manufacturing techniques consist of multiple layers of ceramic material (green tape), which are 100 μm thick and placed on top of each other when the circuit

structure is assembled. Before the heat treatment, which is performed as the final treatment, the ceramic material is still soft, and thus it is possible to make cavities and vias of the desired shape in the ceramic layers. It is also possible to make various electrically passive elements and the above-mentioned conductors on the desired points with silk screen printing. When the desired circuit unit is structurally complete, the ceramic multilayer structure is fired in a suitable temperature. The temperature used in the LTCC technique is around 850°C and in the HTCC technique around 1600°C. However, the problem of microstrips, strip lines and coplanar conductors made with these techniques is the high attenuation per unit of length, low power margin and relatively low ElectroMagnetic Compatibility (EMC). These problems limit the use of these conductor structures in the applications where the above-mentioned properties are needed.

The objective of the invention is to accomplish a waveguide structure implemented with multilayer ceramics, by which the above-mentioned drawbacks of the prior art guide structure can be reduced.

The method according to the invention is characterized in that for creating a waveguide in the direction of the z-axis:
- at least two impedance change points in the direction of the yz plane of the structure are formed in the structure to limit the length a of the core of the waveguide in the direction of the x-axis, and
- that in the xz plane, the core of the waveguide is limited with a first and a second layer of conductive material, which is silk screen printed on top of the ceramic layers that form the core of the waveguide, and which conductive planes are used to limit the length b of the core of the waveguide in the direction of the y-axis.

The waveguide according to the invention is characterized in that it comprises:
- the core part of the waveguide of the structure of the circuit unit in the direction of the z-axis,
- at least two points of impedance discontinuity in the yz-plane, by which the length a of the core part of the waveguide has been limited in the direction of the x-axis, and
- a first and a second layer of conductive material in the xz plane, by which layers the dimension b of the core part of the waveguide has been limited in the direction of the y-axis.

Some preferred embodiments of the invention are described in the dependent claims.

The basic idea of the invention is the following: A waveguide fully integrated into the structure is manufactured with the multilayer ceramic technique. The core part of the waveguide is made of dielectric material with a suitable permittivity ε_r, which is separated from the rest of the ceramic structure in one plane by two layers of conductive material forming parallel planes, and in another plane, which is perpendicular to the previous planes, by two cavities filled with air and/or joining holes filled with conductive material.

The invention has the advantage that the waveguide can be manufactured simultaneously with other components manufactured with the multilayer ceramic technique.

In addition, the invention has the advantage that the feeding arrangement of the waveguide can be implemented with the same multilayer ceramic technique.

The invention also has the advantage that the manufacturing costs of a waveguide manufactured with the method are lower than those of a waveguide made of separate components and joined to the structure in a separate step.

Furthermore, the invention has the advantage that it has a good EMC protection as compared to a strip line, microstrip or coplanar conductor.

In the following, the invention will be described in more detail. Reference will be made to the accompanying drawings, in which

Figure 1 shows an ordinary, air-filled waveguide made of conductive material,

Figure 2 shows an exemplary embodiment implemented with the multilayer ceramic technique, in which the side walls of the waveguide are formed of cavities filled with air,

Figure 3 shows another exemplary embodiment implemented with the multilayer ceramic technique, in which the side walls of the waveguide are formed of air-filled cavities and vias in the vicinity thereof, filled with conductive material,

Figure 4 shows an example of a waveguide according to the second embodiment of the invention implemented with the multilayer ceramic technique as a section in the x-y plane,

Figure 5a shows an example of one way according to the invention to excite a waveform capable of propagating in the waveguide according to the first embodiment of the invention,

Figure 5b shows an example of another way according to the invention to excite a waveform capable of propagating in the waveguide according to the first embodiment of the invention,

Figure 5c shows an example of a third way according to the invention to excite a waveform capable of propagating in the waveguide according to the first embodiment of the invention,

Figure 6a shows an yz-plane presentation of one way of joining a waveguide according to an embodiment of the invention to a microstrip conductor, and

Figure 6b shows an yz-plane presentation of fitting the feeding point of a waveguide according to the invention to a waveguide.

Figure 1 was presented in connection with the description of the prior art. In connection with the description of Figures 2 to 6, reference is made to the directions of the axes x, y and z shown in Figure 1. The directions of the axes are the same as those shown in the example of Fig. 1, although the axes are not drawn in all the figures.

Figure 2 shows an example of a waveguide according to the first embodiment of the invention, implemented with the multilayer ceramic technique. The structure shown in Fig. 2 is part of a larger circuit structure implemented with the multilayer ceramic technique, which is not shown in its entirety in the drawing. The waveguide structure is surrounded on both sides by the structures 21 and 27 shown in the drawing, which consist of several green tapes. The permittivity ε_r of the ceramic material used in them is clearly higher than the permittivity of air, which is of the magnitude 1, as is well known. Other parts of the structure, which are both above and below the waveguide structure shown in the drawing, viewed in the direction of the y-axis, consist mainly of the same ceramic material. The core part 23 of the waveguide consists of the same ceramic material as the rest of the circuit structure. The width of the waveguide in the direction of the x-axis is limited by air-filled cavities 22 and 26 essentially in the direction of the yz plane. The interface of the air-filled cavity 22 or 26 forms a discontinuity of the characteristic impedance against the core part 23 in view of the electromagnetic wave front. This

discontinuity of the characteristic impedance mainly reflects the wave front, which is capable of propagating in the core part 23 of the waveguide, back to the core part 23, while the wave front propagates in the direction of the z-axis. The waveguide is limited in the xz-plane by a first surface 24 and a second surface 25, which are made of some conductive material and which form essentially parallel planes. These planar surfaces 24 and 25 can be made either such that they completely cover the core part 23 or partly gridded. These planar, conductive surfaces 24 and 25 can be made, for example, of conductive pastelike material, by metallizing the surfaces of the core part 23 in these planes or also by covering the core part 23 by separate, thin, conductive filmy material.

In the waveguide according to the first embodiment of the invention, the lowest possible propagating waveform is the TEM (Transverse-electromagnetic) waveform, the electric or magnetic field of which does not have a component in the direction of the z-axis of the drawing. The cut-off frequency of this waveform is 0 Hz, as is known, which means that direct current can flow in the waveguide. A waveguide according to the first embodiment of the invention can also transmit other higher, possibly desired TE_{mn} or TM_{mn} (Transverse-magnetic) waveforms, the corresponding cut-off frequencies of which can be calculated according to the dimensioning rules of an ordinary waveguide, which dimensioning rules have been presented in connection with the description of Fig. 4.

Figure 3 shows an example of a waveguide according to the second embodiment of the invention. The structure shown in Fig. 3 is part of a larger structure implemented with the multilayer ceramic technique, which is not shown in its entirety in the drawing. The waveguide structure is surrounded on both sides by the structures 31 and 37 shown in the drawing, which consist of several green tapes. The permittivity ε_r of the ceramic material used in them is clearly higher than the permittivity of air, which is of the magnitude 1. Other parts of the structure, which are both above and below the waveguide structure shown in the drawing, viewed in the direction of the y-axis of the drawing, also consist mainly of the same ceramic material. The core part 33 of the waveguide consists of the same ceramic material as the rest of the circuit structure. The width of the waveguide in the direction of the x-axis is limited by two essentially parallel impedance discontinuities, which are formed of via posts 38 and 39 in the direction of the y-axis of the drawing together with the air-filled cavities 32 and 36. The air-filled cavities 32 and 36 have a similar construction as was presented in connection with the description of the cavities shown in Fig. 2. The via posts 38, 39 are filled with conductive, pastelike material in connection with the

manufacture of the circuit structure. When the LTCC technique is used, either AgPd paste or Ag paste can be used advantageously. If the waveguide structure according to the invention is entirely surrounded from all sides by other ceramic layers, the cheaper Ag paste can be used. If part of the created waveguide structure remains exposed to the external atmosphere, the more expensive AgPd paste must be used. The via posts 38, 39 combine the essentially parallel first plane 34 and second plane 35, which are formed of conductive material and which limit the core part 33 in the xz plane.

In the embodiment shown in Fig. 3, one via post 38 and 39 for each side of the core part are shown in the drawing as viewed in the direction of the x-axis. The waveguide structure according to the invention can also be implemented by adding several similar via posts to the core part 33. It is also possible to add more similar via posts to the parts 31 and 37 of the circuit structure behind the air cavities 32 and 36, whereby the EMC properties of the waveguide are further improved.

Figure 4 shows an example of a structure according to the second embodiment of the invention as a section in the xy plane. The ceramic circuit structure is assembled by layers of ceramic plates/strips 41. The waveguide is separated from the rest of the structure in the direction of the x-axis by air-filled cavities 42 and 46 in the direction of the yz plane, the width of which cavities is the measure L shown in the drawing and the height is the measure b shown in the drawing, and via posts 48 and 49 filled with conductive material. The core part 43 of the waveguide is formed by ceramic material, the permittivity ε_r of which is high compared to air. The width of the core part of the waveguide in the direction of the x-axis in denoted by the letter a in the drawing. The width L of the air-filled cavities 42 and 46 in the x-plane is selected such that its magnitude corresponds to a fourth of the wavelength of the cut-off frequency f_c. Then the waveguide structure emits as little interference radiation as possible to its environment. In the xz plane, which is perpendicular to the surface shown in Fig. 4, the waveguide is limited by a first plane 44 and a second plane 45, which are essentially parallel and made of conductive material. The first plane 44 and the second plane 45 are connected to each other by vias 48 and 49, which are filled with conductive material. The waveforms TE_{mn} and TM_{mn} can propagate in a waveguide according to the embodiment shown in the drawing. The cut-off frequencies f_{cmn} of these waveforms are obtained from the known formula:

$$f_{cm,n} = \frac{1}{2\sqrt{\mu\,\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

In the formula, the indexes m and n refer to the number of maximums in the direction of the x and y axes of the transverse field distribution of the TE_{mn} or TM_{mn} waveform, measure a denotes the width of the waveguide in the direction of the x-axis, and measure b denotes the height of the waveguide in the direction of the y-axis. The terms μ and ε in the formula are the permeability and permittivity values of the ceramic material of the core part 43 of the waveguide.

Figures 5a, 5b and 5c show three different examples of how the desired waveform can be excited in waveguides according to the invention. The waveguide used in the examples of the figures is a waveguide according to the first embodiment, but the solutions function in accordance with the same principle in waveguide structures according to the second embodiment of the invention as well.

In the example of Figure 5a, the core 53a of the waveguide is separated from the rest of the circuit structure, which is represented by parts 51a and 57a of the structure in the drawing, by air-filled cavities 52a and 56a and a first plane 54a and a second plane 55a, which are essentially parallel and made of conductive material. In order to excite the desired waveform, a hole 58a has been made at the desired point in the first plane 54a of the waveguide. When a radiating element, which is not shown in the drawing, is placed in the vicinity of the hole 58a, the result is that part of the field radiated by the element is transferred through the hole 58a to the waveguide according to the invention. The radiating element can be any circuit element capable of radiating, or possibly another waveguide according to the invention, in the wall of which a hole of corresponding shape and capable of radiating has been made. By selecting the radiating frequency correctly, an electromagnetic waveform of the desired kind and capable of propagating can be excited in the waveguide.

Figure 5b shows another possible way of exciting a waveform capable of propagating in a waveguide according to the invention. In the example of Figure 5b, the core 53b of the waveguide is separated from the rest of the circuit structure, which is represented in the drawing by parts 51b and 57b, by air-filled cavities 52b and 56b and a first plane 54b and a second plane 55b, which are essentially parallel and made of conductive material. In order to excite the desired waveform, there is a hole 58b made at the desired point of the conductive first plane 54b, and the hole is fitted with a cylindrical probe 59b leading to the core part 53b of the waveguide.

The probe is preferably made of the same conductive material as the planar first surface 54b and second surface 55b of the waveguide. The probe 59b is connected to the desired signal inputting conductor in the circuit structures above the planar first surface 54b. The signal conductor can be a strip line or a microstrip, for example. The conductor and other circuit structures above are not shown in Fig. 5b.

Figure 5c shows a third possible way of exciting a waveform capable of propagating in a waveguide according to the invention. In the example of Figure 5c, the core 53c of the waveguide is separated from the rest of the unit, which is represented in the drawing by parts 51c and 57c, by air-filled cavities 52c and 56c and a first plane 54c and a second plane 55c, which are essentially parallel and made of conductive material. In order to excite the desired waveform in the waveguide, there is a hole 58c made at the desired point of the first plane 54c made of conductive material, and the hole is fitted with a coupling loop 59c leading to the core part 53c of the waveguide. The coupling loop 59c is connected to the desired signal inputting conductor in the circuit structures above the planar first surface 54c. The signal conductor can be, for example, a stripline, microstrip or a coplanar conductor. The signal inputting conductor and other circuit structures above are not shown in Fig. 5c. The coupling loop 59c is manufactured of conductive material in connection with the manufacture of the rest of the circuit structure implemented with the multilayer ceramic technique.

Figure 6a shows, by way of example, how the microstrip and the waveguide according to the invention can be joined together. The figure shows a section in the yz plane of the point where the conductors are connected. The circuit structure has been implemented by joining together several layers of ceramic plates 61a. The portion of the microstrip 60a is formed by the signal conductor 63a and the ground conductor 62a. The impedance of the transmission line changes at the point where the microstrip and the waveguide 68a are joined together. High impedance mismatches cause an undesired reflection of the signal back to its incoming direction in the above-mentioned interface. This reflection problem can be diminished by making at the joint a special structure, in which the impedance level of the transmission line is gradually changed. In the example of Fig. 6a, this matching of the impedances has been implemented by a so-called quarter-wave transformer 67a. It consists of steplike changes of the waveguide geometry of the length of $\lambda/4$ in the direction of the z-axis in the drawing. In Fig. 6a, it is accomplished by means of conductive plane surfaces 66a, which are connected to each other in the direction of the y-axis by vias 64a made of conductive material. In

the direction of the x-axis, these planes 66a reach across the whole core part of the waveguide. The electric properties of the ceramic material used in the structure are similar in all parts of the circuit structure in the example of the drawing.

Figure 6b shows an example of another way of joining a waveguide according to the invention to another electric circuit. The figure shows a section in the yz plane of the point where the transmission lines are connected. The circuit structure of the component has been implemented by joining together several layers of ceramic plates 61b. The exciting signal is brought to the waveguide by means of a cylindrical probe 63b. In the example of the drawing, the probe comes to the waveguide 68b through the first plane 62b, which forms the upper surface of the waveguide, and a hole 69b made in the plane. Thus the probe 63b does not have a galvanic connection to the conductive first plane 62b. The probe 63b itself may reach through several ceramic circuit structures in the direction of the y-axis of the drawing, when required. The impedance mismatch created at the feeding point of the signal is reduced by a quarter-wave transformer 67b of the kind described in connection with Figure 6a. The quarter-wave transformer 67b consists of conductive plane surfaces 66b, which are connected to each other in the direction of the y-axis of the drawing by vias 64b made of conductive material. In the direction of the x-axis of the drawing, these planes 66b reach across the whole core part of the waveguide. The electric properties of the ceramic material used in the structure are similar in all parts of the circuit structure in the example of the drawing.

Calculatory simulations have been performed on the embodiments of the waveguides according to the invention. The simulations have been performed on both embodiments according to the invention with the same structural dimensions, whereby the measure a of the core part of the waveguide has been 5 mm, measure b 2 mm, ε_r of the ceramic material 5.9 and the measure L in the direction of the x-axis of the air-filled cavities that are part of the waveguide structure 2.5 mm. A mode of operation according to TE_{10} has been used in the simulation, and the frequency used has been 18 GHz. As a result of the simulation, the first embodiment according to the invention had an attenuation of 1.7 dB/cm. With the same structural dimensions a and b and the same frequency 18 GHz, the waveguide structure according to the second embodiment of the invention had an attenuation value of 0.7 dB/cm.

Some preferred embodiments of the invention have been described above. However, the invention is not limited to the solutions described above. The inventive idea can be applied in many different ways within the scope defined by the attached claims.

Claims

1. A method for manufacturing a waveguide in circuit structures manufactured with the multilayer ceramic technique, in which method the dimensions and structural directions of the circuit structures can be determined by means of x, y and z axes perpendicular to each other, and the circuit unit is assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape are made and on the surface of which ceramic layer a conductive layer of material (24, 25, 34, 35, 44, 45, 54a, 54b, 54c, 55a, 55b, 55c, 62a, 62b, 65a, 65b) is silk screen printed on the desired location, and the circuit structure is completed by exposing the circuit structure to a high temperature, **characterized** in that for creating a waveguide essentially in the direction of the z-axis
- at least two impedance discontinuities essentially parallel with the yz plane of the structure and of the length of the waveguide are formed in the circuit structure to limit the length a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis, and
- that in the xz plane the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide is limited by essentially parallel first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) and second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) planes of conductive material, which are manufactured above and below the ceramic layers that form the core part of the waveguide in the direction of the y-axis, and which conductive first and second planes are used to limit the measure b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis.

2. A waveguide manufacturing method according to Claim 1, **characterized** in that said two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished by forming air-filled cavities (22, 26) essentially in the direction of the z-axis on both sides of the core part (23) of the waveguide in the structure.

3. A waveguide manufacturing method according to Claim 1, **characterized** in that two impedance discontinuities of the length of the waveguide essentially in the direction of the yz plane of the structure are accomplished
- by forming air-filled cavities (32, 36) essentially in the direction of the z-axis on both sides of the core part (33) of the waveguide in the structure
- and by placing in the core part (33) of the waveguide close to both air-filled cavities (32, 36) at least one row of vias (38, 39) filled with conductive material and

essentially in the direction of the y-axis, by which said first (34) and second (35) planes of conductive material are galvanically connected.

4. A waveguide integrated into circuit units manufactured with the multilayer ceramic technique, wherein the dimensions and structural directions of the circuit units can be determined by means of x, y and z axis perpendicular to each other, and the circuit unit has been assembled of separate ceramic layers (41, 61a, 61b), the permittivity ε_r of which is higher than the corresponding value of air, and in which layers cavities (22, 26, 32, 36, 42, 46, 52a, 52b, 52c, 56a, 56b, 56c) and holes (38, 39, 48, 49, 64a, 64b) of the desired shape have been made, and on the surface of which ceramic layers a layer of conductive material has been made on the desired location, **characterized** in that the waveguide comprises:
- a core part of the waveguide (23, 33, 43, 53a, 53b, 53c) essentially in the direction of the z-axis of the structure of the circuit unit,
- at least two impedance discontinuities essentially in the direction of the yz plane, essentially parallel and of the length of the waveguide, which limit the dimension a of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the x-axis, and
- a first (24, 34, 44, 54a, 54b, 54c, 62a, 62b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, and a second (25, 35, 45, 55a, 55b, 55c, 65a, 65b) layer of conductive material essentially in the direction of the xz plane and essentially of the length of the waveguide, which first and second layers are essentially parallel and which limit the dimension b of the core part (23, 33, 43, 53a, 53b, 53c) of the waveguide in the direction of the y-axis.

5. A waveguide according to Claim 4, **characterized** in that said impedance discontinuities essentially in the direction of the yz plane have been formed by means of the air-filled cavities (22, 26) and the interface of the core part (23).

6. A waveguide according to Claim 4, **characterized** in that said impedance discontinuities essentially in the direction of the yz plane have been formed
- of air-filled cavities (32, 36) placed essentially in the direction of the z-axis on both sides of the core part of the waveguide, and
- of vias (38, 39) essentially in the direction of the y-axis, filled with conductive material and placed in at least one row in the core part (33) of the waveguide close to both air-filled cavities, by which vias said first and second layers have been connected.

7. A waveguide according to Claim 4, **characterized** in that a hole (58a) has been made in the first surface (54a) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

8. A waveguide according to Claim 4, **characterized** in that a hole (58b) has been made in the first surface (54b) of the waveguide, through which hole a probe (59b) has been led to the core part (53b) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

9. A waveguide according to Claim 4, **characterized** in that a hole (58c) has been made in the first surface (54c) of the waveguide, through which hole a coupling loop (59c) has been led to the core part (53c) of the waveguide for exciting the electromagnetic field intended to propagate in the waveguide.

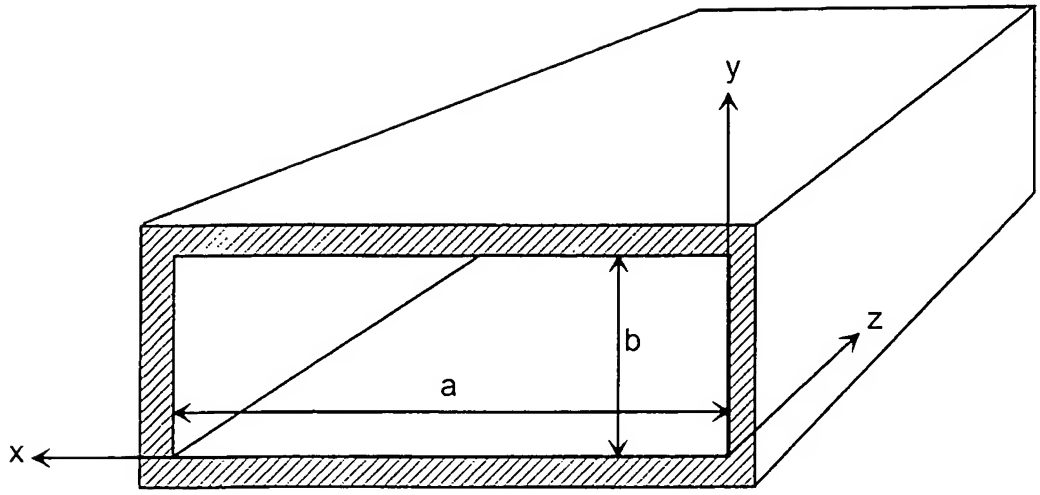


Fig. 1

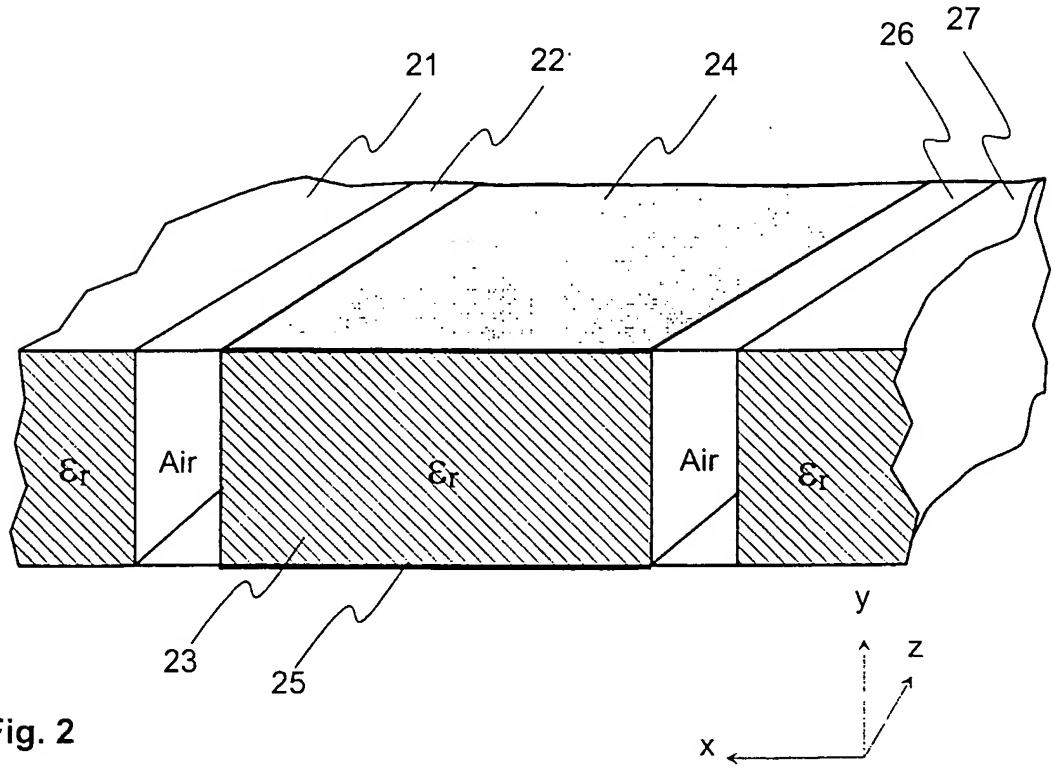
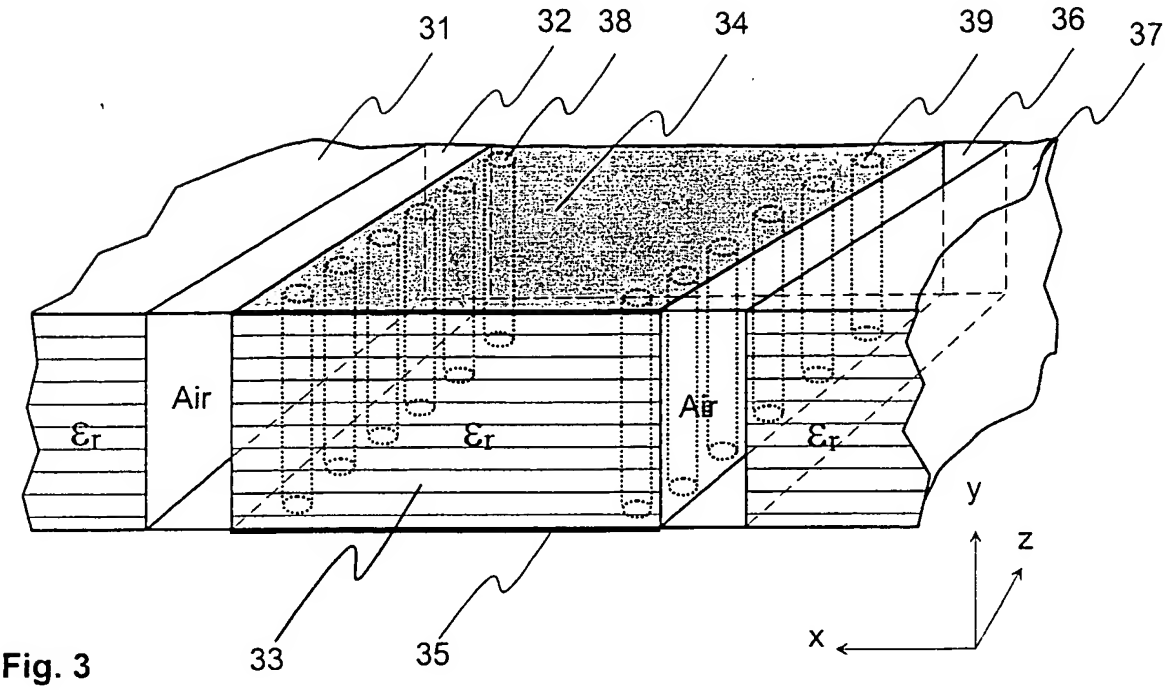


Fig. 2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38
34
39
36
37
Air
Air
εr
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z
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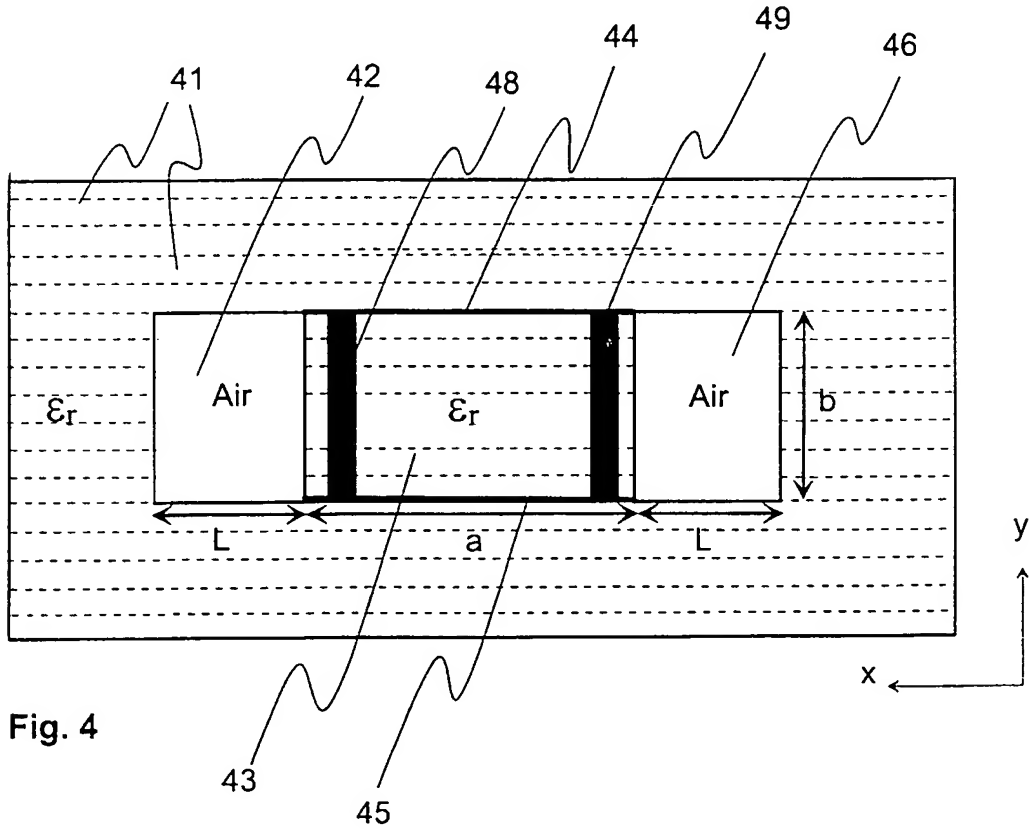
33
35

Fig. 3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42
48
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49
46
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εr
b
L
a
L
y
x
43
45

Fig. 4

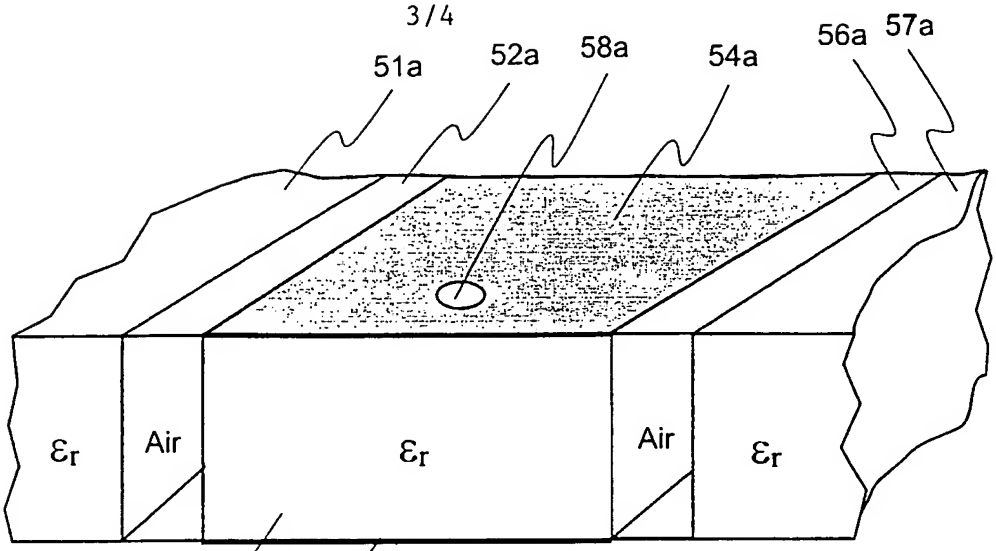

Fig. 5a

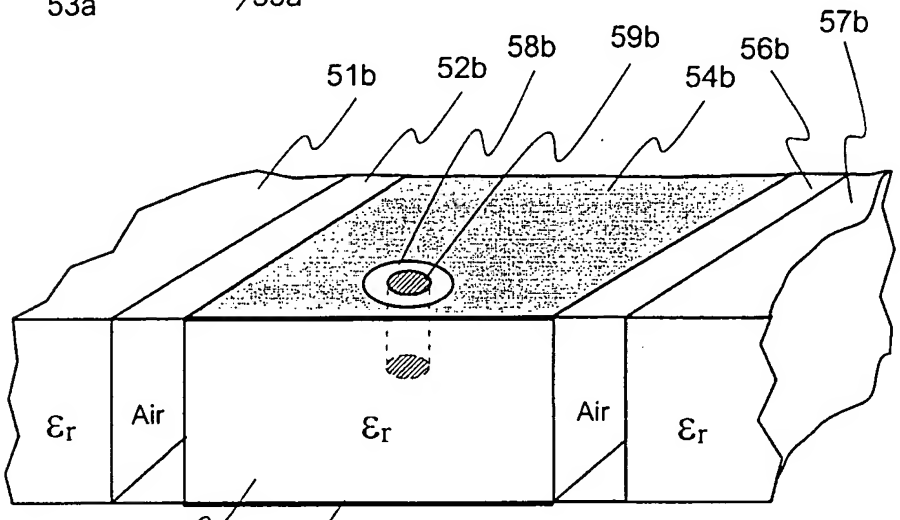

Fig. 5b

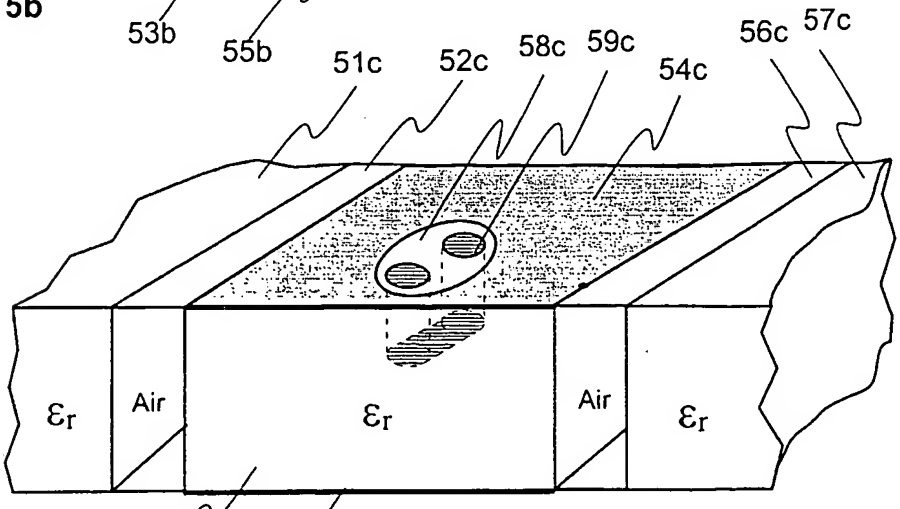

Fig. 5c

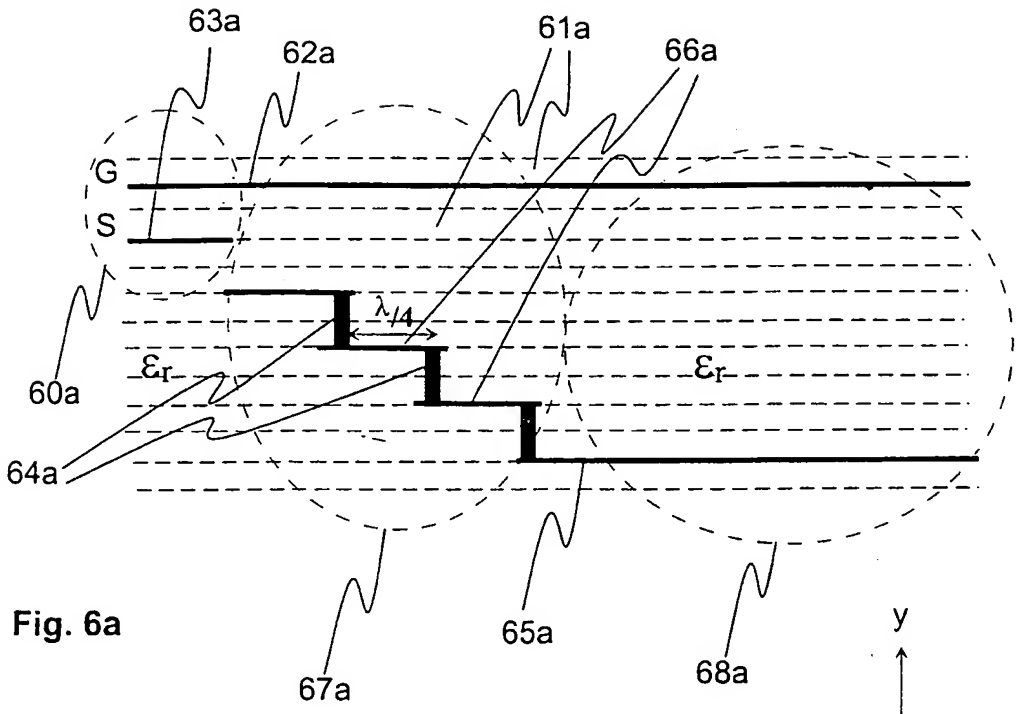
63a
62a
61a
66a
G
S
λ/4
εr
εr
60a
64a
67a
65a
68a
y
z

Fig. 6a

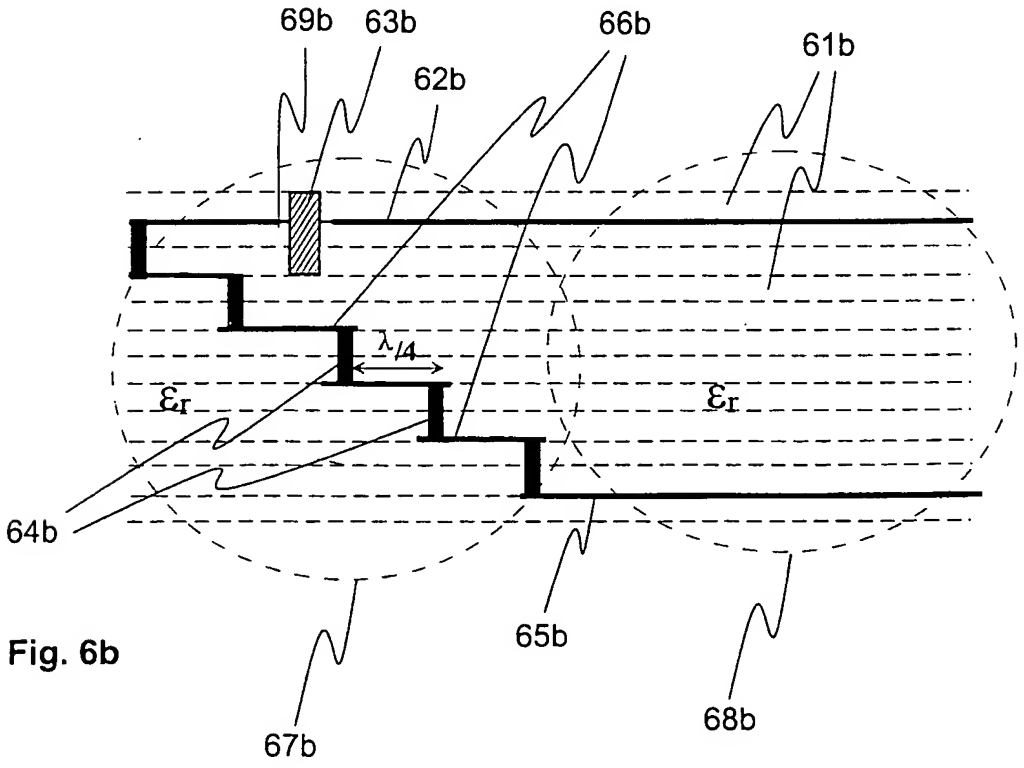
69b
63b
66b
61b
62b
λ/4
εr
εr
64b
67b
65b
68b

Fig. 6b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00635

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01P 3/16, H05K 1/02, H05K 3/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, H01P, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0883328 A1 (KYOCERA CORPORATION), 9 December 1998 (09.12.98), column 2, line 26 - column 3, line 54; column 5, line 20 - column 8, line 50; column 10, line 7 - column 12, line 56, figures 1,5	1,4,7-9
A	--	2,5
A	EP 0858123 A2 (MURATA MANUFACTURING CO., LTD.), 12 August 1998 (12.08.98), column 1, line 55 - column 3, line 22; column 4, line 6 - line 50; column 7, line 11 - line 39	1,2,4,5
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2000	24 -10- 2000

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00635

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0767507 A1 (MURATA MANUFACTURING CO., LTD.), 9 April 1997 (09.04.97), column 3, line 16 - column 6, line 22; column 8, line 19 - column 10, line 11 -- --------	1,2,4,5,7-9

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI 00/00635

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0883328 A1	09/12/98	JP 10303608 A	13/11/98
		US 5982256 A	09/11/99
EP 0858123 A2	12/08/98	CN 1195902 A	14/10/98
		JP 10224120 A	21/08/98
EP 0767507 A1	09/04/97	CN 1152804 A	25/06/97
		JP 2998614 B	11/01/00
		JP 9102706 A	15/04/97
		KR 192562 B	15/06/99
		US 5982255 A	09/11/99